USAID
FROM THE AMERICAN PEOPLE

CRITICAL WATERSHED ANALYSIS

Nicaragua

TECHNICAL REPORT

CRITICAL WATERSHED ANALYSIS
NICARAGUA

Conservation and Sustainable Tourism in Critical Watersheds
Jerry Bauer, Team Leader

By

Jerry Bauer
Assistant Director
USDA Forest Service
International Institute of Tropical Forestry
Río Piedras, Puerto Rico

Wayne J. Arendt Ph.D.
Research Ornithologist and Wildlife Scientist
USDA Forest Service
International Institute of Tropical Forestry
Río Piedras, Puerto Rico

Olga Ramos
GIS Expert
USDA Forest Service
International Institute of Tropical Forestry
Río Piedras, Puerto Rico

Marvin A. Tórrez Gutiérrez
Biologist and Environmental Ecologist
USDA Forest Service
International Institute of Tropical Forestry
Río Piedras, Puerto Rico

In collaboration with

MARENA/COMAP
Fundación Cocibolca
Universidad de Ciencias Comerciales
Red de Reservas Privadas de Nicaragua

Paso Pacífico
Red Nicaragüense de Biodiversidad
Universidad Nacional Autónoma de Nicaragua
Fauna & Flora International

Nicaragua, January 2008

USAID FROM THE AMERICAN PEOPLE

INTERNATIONAL INSTITUTE OF TROPICAL FORESTRY

This work was completed with support from the people of the United States through USAID/Nicaragua by the USDA Forest Service International Institute of Tropical Forestry under PASA No. 524-P-00-07-00007-00 (Conservation and Sustainable Tourism in Critical Watersheds), with assistance from local and international partners and collaborators. The contents are the opinions of the authors and do not necessarily reflect the opinion of the United States Government. For further information contact Jerry Bauer at gbauer@fs.fed.us.

TABLE OF CONTENTS

I. INTRODUCTION

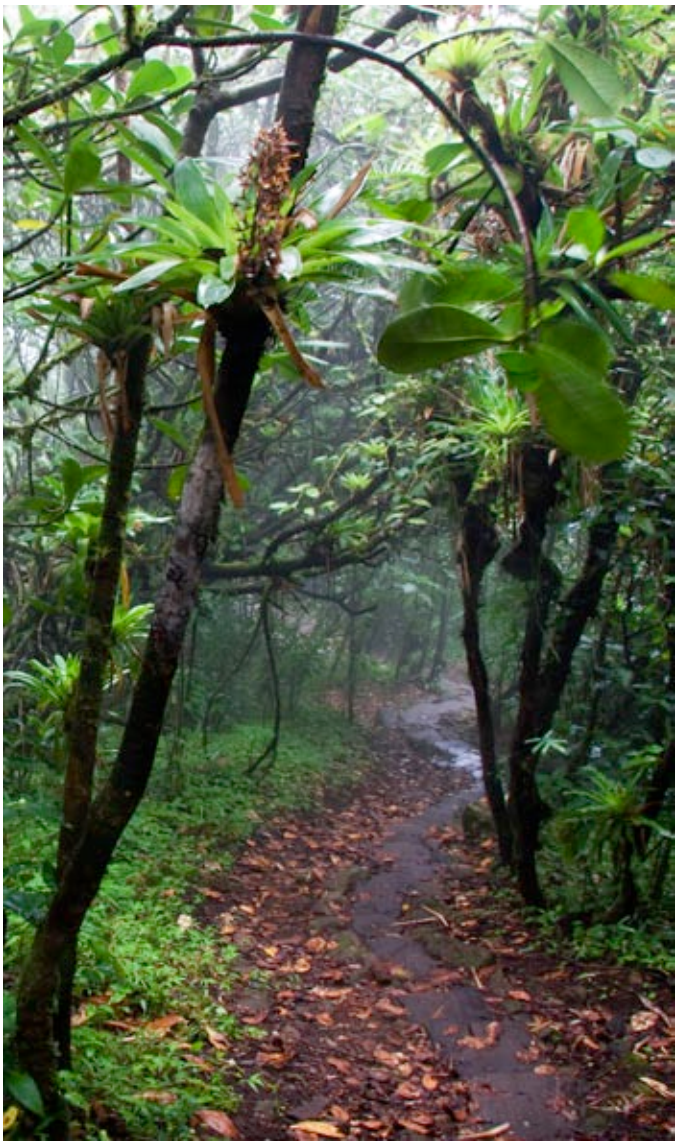
The US Forest Service's International Institute of Tropical Forestry is working with USAID/Nicaragua to assist with implementation of the USAID/Nicaragua Strategic Objective No. 2, "Economic Freedom: Open, Diversified, Expanding Economies", and Intermediate Result, "Improved Management and Conservation of Critical Watersheds". Within this framework, USAID/Nicaragua will assist the Government of Nicaragua (GON), local communities, and the private sector in the development of management systems that conserve natural resources and can be sustained in a competitive, market-oriented environment. In addition to the focus on developing land management capacity, USAID/Nicaragua will focus on developing income-generating activities, such as green market links and sustainable tourism. Such use of natural resources will be consistent with conservation goals for protected areas, forests, and water resources.

This document describes the methodology and the findings of the USFS/IITF Project Team, and it presents recommendations, on which watersheds the Project will be working in during the two-year project period.

BACKGROUND

The earth's climate is complex. It is regulated through the interplay of many factors, from massive events in the sun to microscopic creatures in the oceans. Yet, a clear picture has emerged. Supported by an overwhelming amount of evidence, the world is warming. This warming is due to increasing levels of greenhouse gasses caused by human activity.

Global warming brings with it all the nightmares that haunt natural resource stewards—increased ecological and climatic



disturbances such as desertification, widespread wildfires, cyclones, tornadoes, and all of the direct and indirect consequences stemming from large scale climatic events such as El Niño (and La Niña) Southern Oscillation, increased volcanism and seismic-related disasters on a cosmopolitan scale. Ultimately, and unfortunately for all of us, landscape homogenization and the proliferation of invasive species on an unprecedented scale are just two of the outcomes we are now faced with as a result of our poor stewardship of earth's dwindling and ever increasingly contaminated resources.

The ubiquitous and dynamic alterations of the earth's biomes and major ecosystems that these climate-induced events have brought about, and continue to impact at an accelerating pace, make the land steward's task daunting to say the least. To conserve biodiversity and enhance socio-economic development in the 21st century, conservationists and land managers must balance a complex mosaic of environmental and anthrapogenic variables at a landscape level to preserve plants and animals at the genetic and species levels, and ensure socio-economic sustainability for future generations.

To reach this goal, after months of site visits and assessments, deliberations with international and local biodiversity authorities, economic, and tourism specialists, as well as fact-finding exercises, including extensive literature searches, the USFS/IITF Project Team has evaluated and prioritized Nicaragua's 22 officially designated watersheds, using a combination of biodiversity and socio-economic indicator indices. Six watersheds reflecting the highest scores based on the indicator indices were then selected for this project.

II. OBJECTIVES

To evaluate biodiversity and socio-economical potential within critical watersheds in Nicaragua, and monitor biotic and anthropic changes over time.

SHORT-TERM OBJECTIVES
Create a baseline assessment of plant and wildlife populations for future monitoring
Characterize landscape matrix and select variables for monitoring
Select permanent sites for long-term monitoring
Determine baseline level of function across ecological socio-economic processes in critical watersheds

LONG-TERM OBJECTIVES
Determine directional change of landscape matrix variables
Follow changes in composition of wildlife and flora over time
Monitor population changes in select wildlife and flora
Evaluate changes in ecological processes
Evaluate impact and influence of management and interventions in landscape and biodiversity change, and how it relates to local and regional socio-economic development

III. WATERSHED ANALYSIS

WATERSHEDS IN NICARAGUA

Based on the classification system established by the *Proyecto Hidrometeorológico Centroamericano* (P.H.C.A) en 1970, twenty-two watersheds are contained within Nicaragua's borders (Table 1, Map 1). Watersheds are classified into two drainage areas, the Pacific Ocean and Caribbean Sea drainages. Nine of the watershed drain into the Pacific Ocean (accounting for 10% of the land area drainage) and thirteen into the Caribbean Sea (accounting for 90% of the land area drainage).

TABLE 1. INETER OFFICIALLY RECOGNIZED WATERSHEDS OF NICARAGUA*

No.	Official Watershed		Size (ha)	Drainage
	Number	Name		
1	45	Río Coco	19,969	
2	47	Río Ulang	3,777	
3	49	Río Wawa	5,373	
4	51	Río Kukalaya	3,910	
5	53	Río Prinzapolka	11,292	
6	55	Río Grande de Matagalpa	18,445	Caribbean
7	58	Río Negro		
8	57	Río Kurinwas	4,457	
9	59	Entre Río Kurinwas y Río Escondido (Pearl Lagoon Basin)	2,034	Caribbean
10	60	Río Estero Real	3,691	
11	61	Río Escondido	11,650	
12	6	Entre Río Estero Real y Volcán Cosigüina	429	
13	63	Entre Río Escondido y Río Punta Gorda	1,593	
14	64	Entre Volcán Cosigüina y Río Tamarindo	2,951	
15	65	Río Punta Gorda	2,868	
16	66	Río Tamarindo	318	
17	67	Entre Río Punta Gorda y Río San Juan	2,229	
18	68	Entre Río Tamarindo y Río Brito	2,769	
19	69	Río San Juan en Nicaragua	29,824	Caribbean
20	70	Río Brito	274	Pacific
21	72	Entre Río Brito y Río Sapoá	325	Pacific
22	80	Apanas		Caribbean

* Source: Instituto Nicaragüeense de Estudios Territoriales (INETER). 2005. Mapa de la República de Nicaragua, Cuencas Hidrográficas.

MAP 1.WATERSHEDS OF NICARAGUA

SELECTION CRITERIA FOR CRITICAL WATERSHEDS

The USFS/IITF Project Team is mandated to select "Critical Watersheds" from the twenty-two INETER officially recognized watersheds in which to carry out project activities (see Map 1). Thus, the Project Team developed a methodology and a set of selection criteria that facilitate the efficient allocation of the Project's technical, human, and financial resources and enables the best selection of geographical areas of intervention and institutional clients. The methodology also includes a process for establishing a database that will be useful throughout the entire Project.

The evaluation of Nicaragua's major watersheds, with the objective of selecting a subset of those most representative of the country's biotic and socio-economic diversity, was based on several complimentary and integrative factors. First, we used our previous experience as baseline information resulting from ten years of study, training, and consequential floral and faunal evaluations (sources) in several of Nicaragua's major watersheds.

Next, over a period of several months in 2007, we worked closely with local and international entities by conducting: (a) strategic planning and implementation meetings (see Appendix 1); (b) site visits and preliminary field recognizance and inventory, emphasizing the effective management prescriptions for protected areas provided by PROARCA/CAPAS and based on the methods developed by The Nature Conservancy (TNC); and (c) biodiversity training and technical seminars, as well as several interchanges between IITF GIS lab and several governmental and private entities in Nicaragua and the international community.

Finally, we reviewed pertinent literature on national and international biodiversity and sustainable development issues, needs, and standard evaluation and monitoring methodologies, as well as related publications, and official government reports.

Integrating the results from all our sources (see "Literature Cited"), we combined a preliminary set of about 20 criteria into six. Thus, the final critical watershed selection criteria (Table 2) used for this analysis were:

C1	Key Biological Areas (number/watershed)
C2	Forest fragmentation (index, from high to low)
C3	Development threats in watershed (number of developments)
C4	MARENA priority Protected Areas (number of priority PA in each watershed)
C5	Area of watershed in Protected Areas status (percent of watershed)
C6	Community tourism potential (index, from high to low)

Table 2, on page 7, lists each selection criterion, indicator and information source.

TABLE 2. SELECTION CRITERIA, INDICATORS AND INFORMATION SOURCES USED TO SELECT CRITICAL WATERSHEDS

Criteria		**Indicators**	**Information Sources** (institutions, projects, documents)
C1	Key Biological Areas	Number of KBA per watershed	Ecosystems maps Vegetation maps Protected areas maps Biodiversity maps
C2	Forest fragmentation	Index of fragmentation, high to low	Ecosystems maps Vegetation maps Protected areas maps Biodiversity maps Forest fragmentation maps
C3	Development threats in watershed	Number of developments, underway and planned	Developer maps and plans Interviews with developers Interviews with tourism sector organizations
C4	MARENA priority Protected Areas	Number of priority Protected Areas in each watershed	Memorandums sent to USAID in March 2007 Interviews with MARENA staff COMAP information
C5	Area of watershed in Protected Areas status	Percent of each watershed	Vegetation maps Protected Areas and SINAP maps
C6	Community tourism potential	Index of tourism development potential, high to low	Developer maps and plans Interviews with developers Interviews with local communities Interest levels of communities and individuals

DETAILED DEFINITIONS OF EACH OF THE SIX CRITERIA

CRITERION		DEFINITION
1	**Key Biological Areas** (number/watershed) (data collected–GIS, existing reports, field assessments).	This criterion addresses the key areas of biodiversity in Nicaragua. Key Biodiversity Areas (KBAs) in Nicaragua have been identified based on research conducted by local NGOs. This analysis was based on a prioritization of 1) vulnerability and/or species listed on the IUCN Red List under endangered status and 2) species with restricted geographic range and irreplaceable as a result of reduction in populations. This analysis concentrated on nine taxa, 1) plants, 2) orchids, 3) insects, 4) mollusks, 5) fresh water fish, 6) amphibians, 7) reptiles, 8) birds, and 9) mammals.
2	**Forest Fragmentation** (index, high-medium-low) (data collected–GIS, existing reports, field assessments).	This criterion addresses the amount of fragmentation within forest habitats. GIS data maps of forest and vegetation cover were analyzed to determine an index of fragmentation for each watershed.
3	**Development threats in watershed** (number/watershed) (data collected–developer maps & plans, existing reports, field assessments).	This criterion addresses the amount of tourism development ongoing and planned in each watershed. Existing databases, discussions with developers, GIS data, maps and future plans were accessed to determine the number of active developments in each watershed. A total number of developments in each watershed was determined from this information.
4	**MARENA priority Protected Areas** (number of priority PAs in each watershed (data collected–GIS, existing reports, MARENA assessment, field assessments).	In early 2007 MARENA defined a set of criteria to determine which Protected Areas in the SINAP were a priority to receive USAID funding. They used the following criteria in this process, 1) contribution to socio-economic development, 2) biodiversity importance, 3) social aspects of the PA, 4) institution support in the PAs. This information was summarized and presented to USAID in March 2007 via a memorandum "Propuesta de selección de áreas protegidas para el programa de USAID".
5	**Area of watershed in Protected Area status** (percent of watershed) (data collected-GIS, existing reports).	Maps and databases from MARENA were accessed to determine the number of Protected Areas in each watershed. From this the total percentage of area in Protected Area status was determined.
6	**Community tourism potential** (index, high-medium-low) (data collected-interviews/discussions with local communities, review of ongoing activities, field assessments).	This criterion addresses an important aspect of economic growth—the potential for community tourism development. We used an index ranging from high to medium, to low to rate this criterion. We collected information from existing databases, through interviews with organizations involved in the tourism industry, on-going activities in the watersheds, and potential ecotourism attractions and uniqueness of the area.

MAP DEVELOPMENT

The USFS/IITF GIS laboratory was used to analyze the data collected and to make accurate maps of the watersheds. Matrices were developed to compare analysis and to map out the different parameters and layers of information. These maps were then evaluated to determine the critical watersheds. In addition, GIS maps developed at MARENA and by Fundación Cocibolca were also used in the data analysis.

IV. SELECTED CRITICAL WATERSHEDS

Based on data analysis, and consultations with local experts and the international team of expert advisors, six watersheds were selected for inclusion in the project's scope of work. Four of these are considered as primary and two as secondary critical watersheds. Emphasis will be placed on activities carried out in the primary critical watersheds, but some activities will also take place in the secondary critical watersheds owing to their important role in conserving and managing Nicaragua's remaining natural resource remnants. Table 3 provides background information on each of these watersheds. Map 2 shows the location of each of the selected critical watersheds.

MAP 2. SELECTED CRITICAL WATERSHEDS OF NICARAGUA

TABLE 3. CRITICAL WATERSHEDS DESCRIPTIONS

No.	Official Watershed Number & Name		Basin Drainage	Size (km^2)	Location	Protected Areas in Watershed	
CW 1 Primary	55	Río Grande de Matagalpa	Caribbean	18,445	Central mountains reaching to Caribbean coast	• Reserva Natural Cerro Musún • Reserva Natural Serranía de Quirragua	
CW 2 Secondary	59	Entre Río Kurinwas y Río Escondido (Pearl Lagoon Basin)	Caribbean	2,034	Pearl Lagoon Basin, Caribbean coast	• Pearl Cays • Reserva Natural Cerro Wawashang	
CW 3 Primary	69	Río San Juan en Nicaragua	Caribbean	29,824	Central Pacific	• Reserva de Biósfera del Sureste de Nicaragua • Reserva Natural Volcán Mombacho • Reserva Natural Isla de Ometepe • Reserva Natural Cerro Arenal • Parque Nacional Archipiélago de Zapatera • Refugio de Vida Silvestre Los Guatuzos • Reserva Natural Chocoyero-El Brujo • Parque Nacional Volcán Masaya • Reserva Natural Laguna de Apoyo • Reserva Natural Peninsula de Chiltepe • Reserva Natural Laguna de Asososca • Reserva Natural Laguna de Nejapa • Reserva Natural Complejo Volcánico Momotombo	
CW 4 Secondary	70	Río Brito	Pacific	274	Pacific Southern		
CW 5 Primary	72	Entre Río Brito y Río Sapoá	Pacific	325	Pacific Southern	• Reserva Natural La Flor • RAMSAR designated Wetlands: Sistema de Humedales de la Bahía de Bluefields	
CW 6 Primary	80	Apanás	Caribbean	564	Central Mountains	• Reserva Natural Datanlí-Cerro El Diablo	

	Important Characteristics & Threats
	• Life zone (Holdridge 1996): Tropical Humid Forest, and Tropical Premontane Forest. • Several flora & fauna species listed in KBAs, IBAs and IUCN Red List. • Threats: cattle farming, agriculture frontier expansion.
	• Life zones (Holdridge 1996): Tropical Humid Forest. • Many threatened wildlife species, including IUCN Red Listed Species: West Indian Manatee *(Trichechus manatus)*, Green turtle *(Chelonia mydas)*. • Important marine habitats and sea grass beds, offshore reefs, lagoon estuary, and adjacent wetlands. • Threats: cattle farming, agriculture frontier expansion, colonization, uncontrolled tourism expansion. • This watershed is an important area for conservation of terrestrial and marine vegetation, terrestrial fauna, especially wetlands avifauna and marine fauna.
	• Life zones (Holdridge 1996): Tropical Dry Forest, Tropical Humid Forest, Tropical Premontane Forest, RAMSAR designated wetlands. • Several flora & faunal species listed in KBAs, IBAs and IUCN Red List: Endemic Mombacho Salamander *(Bolitoglossa mombachoensis)*. • Threats: cattle farming, agriculture frontier expansion, fires, deforestation.
	• Life zones (Holdridge 1996): Tropical Dry Forest • IUCN Red Listed Species: Golden-mantled Howling Monkey *(Alouatta palliata)*, White-faced Capuchin (Cebus capucinus), Central American Spider Monkey *(Ateles geoffroyi Rufous)*, Vented Ground-Cuckoo *(Neomorphus geoffroyi)*. • Locally important Species: *Ameiva quadrilineata* • Threats: cattle farming, agriculture, frontier expansion.
	• Life zones (Holdridge 1996): Tropical Dry Forest. • IUCN Red Listed Species: Loggerhead Turtle *(Caretta caretta)*, Green Turtle *(Chelonia mydas)*, Hawksbill Turtle *(Eretmochelys imbricata)*, Yellow-naped parrot *(Amazona auropalliata)*. • Threats: cattle farming, agriculture frontier expansion, uncontrolled tourism expansion.
	• Life zones (Holdridge 1996): Tropical Humid Forest Tropical, Premontane Forest, RAMSAR designated Wetlands –Lago de Apanás, Asturias. • Several flora & faunal species listed in KBAs, IBAs and IUCN Red List; Flagship Species include: Harpy Eagle *(Harpia harpyia)*, Three-wattled Bellbird, Resplendent Quetzal *(Pharomachrus mocinno)*. • Threats include cattle farming, agriculture frontier expansion

Literature Cited

Arendt, W.J., and M.A. Tórrez. (in press). Primer Reporte del Híbrido Intergenérico *Vermivera chrysoptera X Vermivera pinus* ("Brewster's Warbler") en Nicaragua. (Boletín Zeledonia, junio 2008).

Arellano, J.E. 1993. Estudios sobre arqueología y prehistoria de Nicaragua. In *30 años de Arqueología en Nicaragua:* 137-142. MNN, INC. Managua.

Arróliga, O. 1998. Monitoreo de aves en cafetales bajo sombra en la Reserva Natural Volcán Mombacho. En: Mesoamericana. 1998. Memorias de II Congreso y III Asamblea General de la Sociedad Mesoamericana para la Biología y la Conservación. Managua, Nicaragua.

Barany, M.E., A.L. Hammett, B.R. Murphy, and J.K. McCrary. 2002. Resource use and management of selected Nicaraguan protected areas: a case study from the Pacific region. Natural Areas Journal 22:61-69.

Camacho Pacheco, J.J. 2000. Recursos acuaticos y zonas costeras. Managua, Nicaragua: MARENA, Division General de Planificación. 40 p.

Espinoza, E., y R. Garcia. 2001. La administración de los recursos culturales y naturales del archipiélago Zapatera. Huellas 2:95-107.

Espinoza, E., R. Gonzales, y D. Rigat. 1994. Gran Nicoya y la Cuenca del Lago de Nicaragua. Vínculos 18:1957-173.

Gassiot, E., y B. Palomar. 2003. El poblamiento precolonial de las tierras altas. Revista de Historia de Ciencias Sociales 1:5-13.

Gillespie, T.W., K.E. Nicholson, and J.K. McCrary. 2001. Patterns of vertebrate species richness and conservation in Nicaragua. Natural Areas Journal 21:159-167.

Gutiérrez Ramírez, M. 2007. Comportamiento poblacional de aves y biometría de *Elaenia frantzii* en el bosque nuboso de la Reserva Natural Volcán Mombacho. Trabajo monográfico para optar al título de Licenciada en Ciencias Biológicas, Universidad Nacional Autónoma de Nicaragua, Recinto Universitario Rubén Darío Facultad de Ciencias e Ingeniería, Departamento de Biología. Managua, Nicaragua. 76 pp.

Haberland, W. 1963. Arqueología de Ometepe. Instituto Indigenista Nacional No. 37:14-15, Managua.

Harvey, C.A. 2008. Evaluación y conservación de biodiversidad en paisajes fragmentados de Mesoamérica (Celia A. Harvey y Joel Sáenz Méndez, eds.). 1ª ed. Santo Domingo de Heredia, Costa Rica: Instituto Nacional de Biodiversidad, INBio. 624 p.

Healy, P.F. 1980. The Archaeology of the Rivas Region, Nicaragua. Wilfred Laurier University, Waterloo, Ontario.

Hurtado de Mendoza, L. 2000. Biodiversidad en Nicaragua: un estudio de país. Managua, Nicaragua: MARENA, Dirección General de Biodiversidad y Recursos Naturales; PANIF. 89 p.

IUCN. 2008. http://www.iucnredlist.org/

Köhler, G. 2001. Anfibios y Reptiles de Nicaragua. Herpeton, Offenbach, Alemania. 208 p.

Lange, F., S. Payson, y A. Martínez. 1992. The Archaeology of Pacific Nicaragua, University of New Mexico Press, Albuquerque.

Lezama, M. 2003. Nicaragua—Inventario de anátidos, temporada 2003. Ducks Unlimited. 16 p.

Lezama, M. 2005. Nicaragua—Inventario de anátidos, temporada 2004-2005. Ducks Unlimited. 15 p.

MARENA. 1998. Áreas protegidas de Nicaragua. Guía túristica. Managua, Nicaragua: MARENA, AED, USAID, Nicaragua GreenCom. 35 p.

MARENA. 1999. Biodiversidad en Nicaragua: Un estudio de país. MARENA, PANIF. Primera edición, 463 p.

MARENA. 2001. Estrategia nacional de biodiversidad. Imprimatur, Managua. 99 p.

MARENA. 2003. Estado actual del ambiente en Nicaragua 2003. II Informe Geo. Impresión comercial La Prensa, Managua. 177 p.

MARENA. 2004. Indicadores ambientales de Nicaragua. Volumen I. Impresión comercial La Prensa, Managua. 201 p.

MARENA. 2005. Resolución Ministerial No. 051 – 2004. Gaceta, 47, 8.03.05.

Martínez-Sánchez, J.C. 1988. Estudio Biogeografico Comparativo de la Avifauna de Cuatro Áreas Montañosas de Nicaragua (available at: http://www.bio-nica.info/Biblioteca/Martinez-Sanchez1988.pdf)

Martínez-Sánchez, J.C. 1990. Biodiversidad en Nicaragua: Estado Actual de Conocimiento Sobre la Fauna Vertebrada. World Wildlife Fund-US. 12 p.

Martínez-Sánchez, J.C. 2007. *Lista Patrón de las aves de Nicaragua: con información de nuevos registros, distribución y localidades donde observar aves.* Primera edición. Managua, Nicaragua: Alianza para las Áreas Silvestres, ALÁS. 65 p.

Martínez-Sánchez, J.C., J.M. Maes, E. Van Den Berghe, S. Morales, y E. Castañeda. 2001. Biodiversidad zoológica en Nicaragua. PNUD, GEF, MARENA, Managua. 144 p.

Matamoros, J.I. 1998. Diversidad y Abundancia de la avifauna de las haciendas cafetaleras del Volcán Mombacho. Resumen En: Mesoamericana. 1998. Memorias de II Congreso y III Asamblea General de la Sociedad Mesoamericana para la Biología y la Conservación. Managua, Nicaragua.

Maes, J.M. 1999. Insectos de Nicaragua. Secretaría Técnica de Bosawás, MARENA, Managua. III Vols. 1169 p.

Meyrat, A. 2001. Estado de conservación de los ecosistemas de Nicaragua. En: Estrategia Nacional de Biodiversidad. Imprimatur, Managua. 189 p.

McCrary, J.K., W.J. Arendt, L. Chavarría, L.J. López, P.A. Somarriba, P.-O. Boudrault, A. Cruz, and F.J. Muñoz. (under review). Additions to the Nicaraguan avifauna, including species' range extensions, new distributional data, abundance information, and observations of poorly known species. (Cotinga)

McCrary, J.K., W.J. Arendt, S. Morales, J.T. Arengi, and L.J. López (in press). New avian sight records for Nicaragua, with notes on abundance, distribution and habitat use (2008, Cotinga).

Mittermeier, R., N. Myers, and C. Mittermeier. 2000. Hotspots: Earth´s biologically richest and most endangered terrestrial ecoregions. Conservation International. 432 p.

Morales, S, and D. Osorno. 1999. Avifauna en bosque y cafetal con sombra de la Reserva Natural Volcán Mombacho. Resumen En: Mesoamericana. 1999. Memorias de III Congreso y IV Asamblea General de la Sociedad Mesoamericana para la Biología y la Conservación. Nueva Guatemala de la Asunción, Guatemala.

Morales, S., A. Martínez-Salinas, W.J. Arendt, and M.A. Tórrez. (in press). Redescubrimiento de *Dendroica chrysoparia* en Nicaragua. (Boletín Zeledonia, junio 2008)

Moreno, L., H. García, H. Segers, y A. Infante. 1992. Rotifers (Monogononta) of Nicaragua. Ecología, Acta Científica Venezolana 43:243-247.

Moreno, L., y L. Pacheco. 2001. Los copépodos de vida libre de la región del Pacífico de Nicaragua. Encuentro 58:34-41.

Navarro, R. 1982. Recursos Culturales del Archipiélago Zapatera. In Plan Maestro del Parque Nacional Archipiélago Zapatera. IRENA, Managua.

Navarro, R. 1987a. Conservación y Manejo de recursos culturales en áreas naturales de Nicaragua. In Memorias de la II reunión centroamericana de sobre manejo de recursos naturales y culturales. Guatemala, Guatemala.

Navarro, R. 1987b. Los principales sitios arqueológicos y paleontológicos de Nicaragua, problemática, objetivos y perspectivas al ano 2000. En: Memorias del primer taller: prioridades de Nicaragua Hasta el año 2000 en materia de áreas naturales, culturales y legislación ambiental, Managua.

Navarro, R. 1997. Historia de la arqueología de Rivas, In Département de archéologie de Patrimonio Cultural. Managua.

Navarro, R. 2004. Rivas: cuna de cultura ancestral. En revista Nicaracolli Abril-Mayo, Nicaragua.

Pérez, A.M. 2001. Biología pesquera de la Lisa *(Mugil curema)* en las lagunas costeras de la RAAS, Nicaragua. Proyecto DIPAL, Nicaragua. 53 p.

Pérez, A.M. 2001. Biología pesquera del Sábalo Real *(Megalops atlanticus)* en las lagunas costeras de la RAAS, Nicaragua. Proyecto DIPAL, Nicaragua. 48 p.

Pérez, A.M. 2002. Propuesta de Sistema Nacional de Monitoreo de la Biodiversidad. Informe final. MARENA/PNUD/GEF, Managua. 45 p.

Pérez, A.M. 2002. Redes ecológicas: un uso alternativo del término y su aplicación a la conservación in situ. Un enfoque preliminar. GAIA 2:1-10.

Pérez, A.M. 2008. Biodiversidad en Nicaragua: contexto y estado actual. Encuentro 79:96-104

Pérez, A.M., and A. López. 1999. Algunos aspectos relacionados con las parasitosis transmitidas Por Moluscos. Encuentro 51:51-59.

Pérez, A.M., G. Bornemann, L. Campo, I. Arana, M. Sotelo, F. Ramírez, y E. Castañeda. 2003. Biodiversidad y producción en sistemas silvopastoriles de América Central. Cuadernos de investigación de la UCA No. 15. 77 p.

Pérez, A.M., I. Siria, M. Sotelo, y E. Vargas. 2002. Norma técnica para regular la extracción y aprovechamiento sostenible de la concha negra en el Pacífico de Nicaragua. Informe Final, MARENA. Managua. 68 p.

Pérez, A.M., I. Siria, y M. Sotelo. 2005. Propuesta para el Programa de Investigación y Monitoreo de la Biodiversidad en Áreas Protegidos. Informe Final. REDNICABIO/GAIA. 174 p.

Pérez, A.M., I. Siria, M. Sotelo, y E. Vargas. 2004. Aprovechamiento del recurso ostras en el Pacífico de Nicaragua. Informe Final, MARENA. Managua. 57 p.

Pérez, A. M., M. Sotelo, y I. Arana. 2004. Altitudinal variation of Diversity in landsnail communities from Maderas Volcano, Ometepe Island, Nicaragua. Iberus 22:133-145.

Pérez,A.M.,M.Sotelo,F.Ramírez,I.Ramírez,A.López,yI.Siria.2006. Conservación de la biodiversidad en sistemas silvopastoriles de Matiguás y Río Blanco (Matagalpa, Nicaragua). Ecosistemas, versión electrónica: (HYPERLINK "http://www.revistaecosistemas.net/" http://www. revistaecosistemas.net/articulo.asp?Id=429&Id_categoria=2&tipo=portada).

Pérez, A. M., M. Sotelo, y I. Siria, y A. López S.J. 2007. Áreas protegidas prioritarias para la investigación y el monitoreo de la biodiversidad en Nicaragua. Encuentro, Año XXXIX, N° 76:131-150.

Philpott, S.M., W.J. Arendt, I. Armbrecht, P. Bichier, T.V. Diestch, C. Gordon, R. Greenberg, I. Perfecto, R. Reynoso-Santos, L. Soto-Pinto, C. Tejeda-Cruz, G. Williams-Linera, J. Valenzuela, and J.M. Zolotoff (in press). A tri-taxon meta-analysis of biodiversity loss in Latin American coffee landscapes: ants, birds, and trees. (2008, Conservation Biology).

Ramsar Convention on wetlands. 2003. The annotated Ramsar list: Nicaragua. http://www.ramsar.org/profiles_nicaragua.htm (viewed May 29, 2008).

Ryan, J. 1992a. Los arrecifes del caribe nicaragüense. Wani 12:35-52.

Ryan, J. 1992b. Medioambientes marinos de la costa caribe de Nicaragua. Wani 12:25-47.

Sánchez, R. 2001a. Biología pesquera de las Corvinas (Familia Sciaenidae) en las lagunas costeras de la RAAS, Nicaragua. Proyecto DIPAL, Nicaragua. 78 p.

Sánchez, R. 2001b. Biología pesquera de los Róbalos (Centropomus spp.) en las lagunas costeras de la RAAS, Nicaragua. Proyecto DIPAL, Nicaragua. 105 p.

Salas, J.B. 1993. Árboles de Nicaragua. Editorial Hispamer, Managua. 388 p.

Salas, J.B. 2002. Biogeografía de Nicaragua. Impresión Comercial La Prensa, SA, Managua. 547 p.

Siria, I., F. Ramírez, I. Ramírez, M. Pérez, y M. Sotelo. 2005. La biodiversidad en Fincas Ganaderas. Serie Cuaderno de Campo, INPASA. 20 p.

Sobrevila, C. & P. Bath. 1992. Evaluación ecológica rápida. The Nature Conservancy, US. 232 p.

Stauffer, J.R., McCrary, J.K., and K.E. Black. 2008. Three new species of cichlid fishes (Teleostei: Cichlidae) from Lake Apoyo, Nicaragua. Proceedings of the Biological Society of Washington121:117-129.

Stevens, W.D. et al. (Editores). 2001. Flora de Nicaragua. Missouri Botanical Villa, J. 1972. Anfibios de Nicaragua. Instituto Geográfico nacional y Banco Central de Nicaragua, Managua. 216 p.

Walsh, B. 1999. Diversidad de Ecosistemas. Pp. 237-276 en: Biodiversidad en Nicaragua. Un estudio de país. MARENA-PANIF, Managua.

Weaver, P.L., and G.P. Bauer. 2000. Major Meliaceae in Nicaragua. General Technical Report IITF-GTR-10. Río Piedras, PR: USDA Forest Service, International Institute of Tropical Forestry. 38 p.

Weaver, P.L., and F. Díaz Santos. 2002. Mombacho Volcano Natural Reserve, Nicaragua. Mesoamericana 6:26-35.

Weaver, P.L., D.M. Lombardo, y J.C. Martínez Sánchez. 2003. Biodiversity and Tropical Forest Conservation, Protection and Management in Nicaragua: Assessment and Recommendations. Final Report—Evaluation performed for USAID/Nicaragua with USDA Foreign Agricultural Service International Cooperation and Development. 38 p.

Zeas, M., B. Quintero, M.L. Sánchez, S. Motha. 2002. Áreas protegidas. Informe Nacional. GEF/PNUD, Managua. 84 p.

Zolotof-Pallais, J.M., M. Lezama-López, y L. Valerio. 2007. Áreas Claves de Biodiversidad en Nicaragua. Rep. Téc., Fundación Cocibolca. 63 p.

Zolotoff-Pallais, J.M., M. Torres., S. Morales y M. Gutiérrez. 2006. Important Birds Areas (Areas Importantes para Aves) en Nicaragua, Selección preliminar. Fundación Cocibolca y Alianza para las Áreas Silvestres (ALAS). 89 pp.

Zuñiga, T. 1999. Diversidad de especies: fauna. en: Biodiversidad en Nicaragua: Un estudio de país. MARENA-PANIF, Managua. pp. 237-276.

TECHNICAL ADVISORS LIST

APPENDIX I

IITF

1. Jerry Bauer, Project Team Leader, Forestry, Ecotourism
2. Sandra Coria, Assistant Project Leader, Project Coordination
3. Dr. Wayne Arendt, Wildlife Conservation
4. Dr. Kathleen McGinley, Tropical Forest Criteria and Indicators
5. Dr. Eileen Helmer, Landscape Ecologist
6. Dr. Peter Weaver, Tropical Ecologist
7. Olga Ramos, IITF GIS/GPS expert
8. Jorge Paniagua, Project designer and mapping
9. Marvin Tórrez, Biologist and Environmental Ecologist

OTHER US FEDERAL ADVISORS

1. Jeff Luvall, NASA/Tropical Research Ecologist

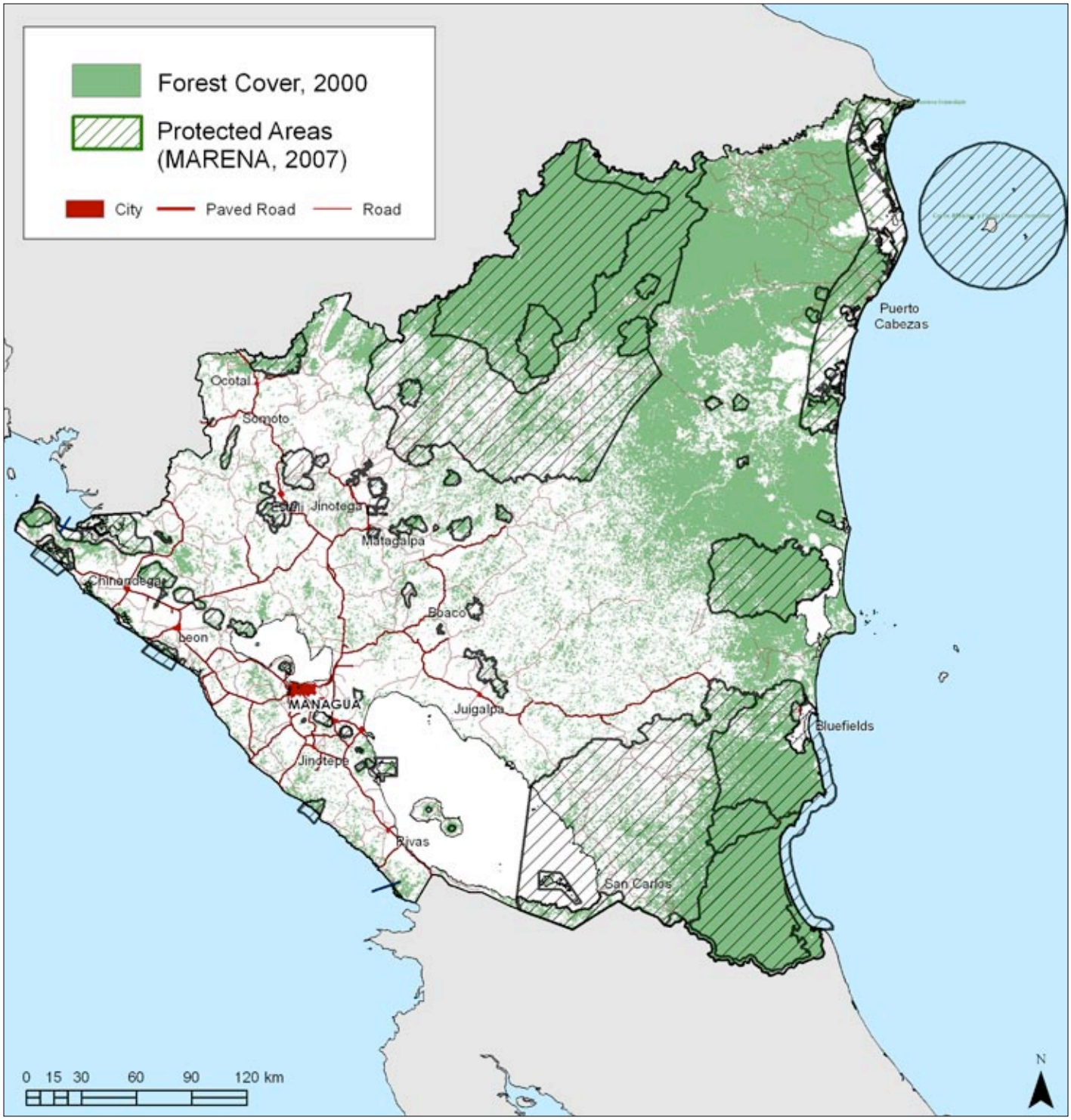
US UNIVERSITIES

1. Cem Basman, Indiana University/Ecotourism Expert
2. Michael Valliant, Indiana University Ecotouirsm Expert

NICARAGUAN UNIVERSITY PARTNERS AND COLLABORATORS

1. Mark Willuhn, Mesoamerica Ecotourism Alliance/ Ecotourism
2. Kathi Campbell, Wildlife Conservation Society
3. Cynthia Lagueux, Wildlife Conservation Society
4. Liza Gonzales, Paso Pacífico
5. Teresa Zuniga, Fauna & Flora International
6. Salvadora Morales, Fauna & Flora International
7. José Manual Zolotoff, Fundación Cocibolca
8. Nuria Dixon Curtis, Pearl Lagoon Communities
9. Dr. Jean Michel Maes, León Entomological Muesum
10. Dr. Mijail Pérez, la Red Nicaraguense de Biodiversidad (REDBIO)
11. Dr. Eric Van den Berghe, Ave Maria University
12. Jose Manual Zolotoff, Fundación Cocibolca (COMAP)
13. Enock Pineda, Fundación Cocibolca (COMAP)
14. Octavio Escobar, Fundación Cocibolca (COMAP)
15. Dr. Enrique Rimbaud (Universidad de Ciencias Comerciales)
16. Noelia Zepeda Obregón (Universidad de Ciencias Comerciales)
17. Dr. Juan Carlos Martínez-Sánchez, (ALAS)
18. Dr. Jeffrey McCrary (FUNDECI/GAIA)
19. Ruth Aguirre Gadea (Directora, Depto. de Biología, UNAN)
20. María Esperanza Zelaya (Directora, Colegio Pierre et Marie Curie)
21. Yader Peralta, RN Chocoyero (COMAP)
22. Edgar Castañeda, FUNDAR (COMAP)
23. Sandra Hernandez. (TNC)
24. Maria Inez Barrios, MARENA
25. Maura Marta Zeas, MARENA/Areas Protegidas/CAFTA
26. Maria Antonieta Rivas, MARENA/CAFTA
27. Rene Castellon, MARENA/CITES/CAFTA
28. Salvador Toruño, MARENA/Dantali
29. Claudia Belli, Red de Reservas Privadas Nicaragua
30. Liliana Duriaux, Red de Reservas Privadas Nicaragua
31. Georges Duriaux, Red de Reservas Privadas Nicaragua
32. Pomares Salmeron, Red de Reservas Privadas Nicaragua
33. Fabrico Diaz, independent consultant
34. Lucy Valenti, CANATUR
35. Sandra Mejia, CANATUR
36. Roger Solorzano, Univ Americana Nicaragua
37. Carlos Sanchez, CLUSA

MAP A1. FOREST COVER OF NICARAGUA



MAP A2. PROTECTED AREAS OF NICARAGUA