Deutscher Tropentag 1999 in Berlin
Session: Biodiversity, Nature Conservation and Development

Identification of conservation priorities in the Bolivian Amazon A new biological-socioeconomic methodology using GIS

Pierre L. Ibisch*[+], Christoph Nowicki*, Rocio Gonzáles, Thomas Oberfrank, Chelsea Specht, Natalia Araujo & Karen Minkowski

Fundación Amigos de la Naturaleza Noel Kempff (F.A.N.), Departamento de Ciencias Casilla 2241, Santa Cruz, Bolivia (pibisch@fan-bo.org)
**Associated Researcher of the Institute of Botany, University of Bonn, Germany.*
[+]*Integrated Expert CIM/GTZ with F.A.N.*

Abstract
The results of a biological and socioeconomic evaluation of the Bolivian Amazon, undertaken for the WWF Bolivia Program Office, are presented. This analysis is based exclusively on already existing information, both published as well as unpublished data. A methodology was developed that would enable us to identify priority areas on which to focus conservation efforts. Furthermore, it was intended that any conclusions concerning the (biologically) desirable goals reflect the temporal-spatial (socioeconomical) urgency and viability. The principal tool for integrating and combining the spatial analyses was a Geographic Information System (GIS): Arc/Info and ArcView with Spatial Analyst). A short overview of important outcomes is also presented.

Keywords: Biodiversity, conservation, priority setting, Bolivia, Amazon, GIS.

1. Introduction
Some of the most important ecological regions of tropical South America are represented in Bolivia, and it is one of the few countries in the world where a major portion of global biodiversity is concentrated within its national boundaries. Bolivia still has some of the most extensive forests in the world, due to low human population density, especially in the lowlands, and to a lack of infrastructure for accessing and rapidly exploiting the country's natural resources. However, recent years have been marked by dynamic economic development. A surge of activities in agro-industry, oil exploitation, timber extraction and road construction is leading to biodiversity degradation, especially in the Amazon lowlands (Ibisch, 1998). Deforestation is the primary factor in the loss of biodiversity in Bolivia. Every year Bolivia loses between 1,780 km^2 (Ministerio de Desarrollo Sostenible y Medio Ambiente, 1995) and 6,200 km^2 of forest (The International Bank for Reconstruction / World Bank, 1994); deforestation rates in the Amazon are increasing.

The Bolivian Amazon, as defined here, encompasses all of Bolivia that is covered by humid evergreen forests below 1,000 m elevation. It extends over 263,096.44 km^2 , corresponding to 24% of Bolivian territory. It forms part of the Southwest Amazon (SWA) ecoregion, which World Wildlife Fund-USA (WWF) identified as one of 200 priority regions of global importance (WWF 1998, Olson & Dinerstein 1998). WWF has decided to support long-term conservation of biodiversity in the SWA ecoregion, using the concept of *Ecoregional Based Conservation* (ERBC).

The ERBC concept was developed by WWF as a means of integrating cutting-edge knowledge of conservation biology and ecosystem management into concrete conservation planning and implementation. The objectives of ERBC are to: a) represent all distinct natural communities, b) maintain ecological and evolutionary processes which generate and maintain biodiversity, c) maintain viable populations of species, d) conserve sufficiently large blocks of natural habitats that can respond as systems to periodical and large-scale and long-term perturbations (Dinerstein et al. 1995, Olson & Dinerstein 1998). The keystone for ERBC is the elaboration of a situation based upon a biological and a socioeconomic evaluation.

Previous prioritization exercises in the Amazon frequently concentrated on a few biological criteria (like species richness and endemism) and were often misleading because of differences in the state of knowledge in different areas (e.g. at Manaus Workshop 90). When WWF entrusted the Sciences Department of the Bolivian conservation NGO *Fundación Amigos de la Naturaleza Noel Kempff* (F.A.N.) with the task of evaluating the biological and the socioeconomic situation in the Bolivian Amazon, the goal was to achieve a basis for a) prioritization of areas and actions that would be as objective as possible (based mainly on biological-ecological values, conservation status, future threats) and b) recommendations for immediate actions considering possible opportunities and limitations for conservation activities. A new GIS-based methodology was developed, which permits the integration of extrapolated biological and socioeconomic data, so that any conclusions concerning the (biologically) desirable goals reflect the temporal-spatial (socioeconomic) urgency and viability.

2. Methods

The method of ecoregional planning preliminarily defined by WWF was modified and specified following the steps listed hereafter:

- Step 1: Delimitation of study area (biological, ecological and geographical criteria)
- Step 2: Biological evaluation – sub-zoning (biological, ecological and geographical criteria)
- Step 3: Biological evaluation – determination of biological-ecological values (see 2.1.)
- Step 4: Development of biodiversity vision (desirable conservation activities exclusively based on results of step 3)
- Step 5: Socioeconomic evaluation – definition of evaluation units (Conservation Units, see 2.2.)
- Step 6: Socioeconomic evaluation – determination of conservation status (see 2.2.)
- Step 7: Socioeconomic evaluation – prediction of future threats (see 2.2.)
- Step 8: Socioeconomic evaluation – determination of opportunities and limitations for conservation activities (see 2.2.)
- Step 9: Situation analysis (“desirability”) – integration of biological and socioeconomic results – identification of spatial and temporal priorities (see 2.3.)
- Step 10: Situation analysis (“action viability”) – viability analysis of conservation activities considering opportunities and limitations
- Step 11: Situation analysis (“biological viability”) – check of prioritized areas comparing them with results of step 4
- Step 12: Ecoregional Action Plan – definition of conservation strategies, programs and activities to be implemented in the priority areas.

2.1. Geographical Information System (GIS) – general aspects

Databases received from the many contributing Bolivian NGO’s and governmental institutions were all projected to a geographic reference system in PC Arc/Info. These data included e.g. river systems, vegetation and forestry coverage, indigenous territorial boundaries, protected areas, population centers, roads and departmental (state) and municipal boundaries. A 15-minute grid was generated in Arc/Info to cover the entire Southwest Amazon ecoregion. The squares, or grid cells, formed the basic spatial unit of the study; each grid cell covers approximately 27.36 km^2. Values for biological and socioeconomic variables were input into the appropriate grid cell in Arc View. PC Arc/Info was also used to create Conservation Units. Maps were produced in ArcView.

2.2. Biological evaluation

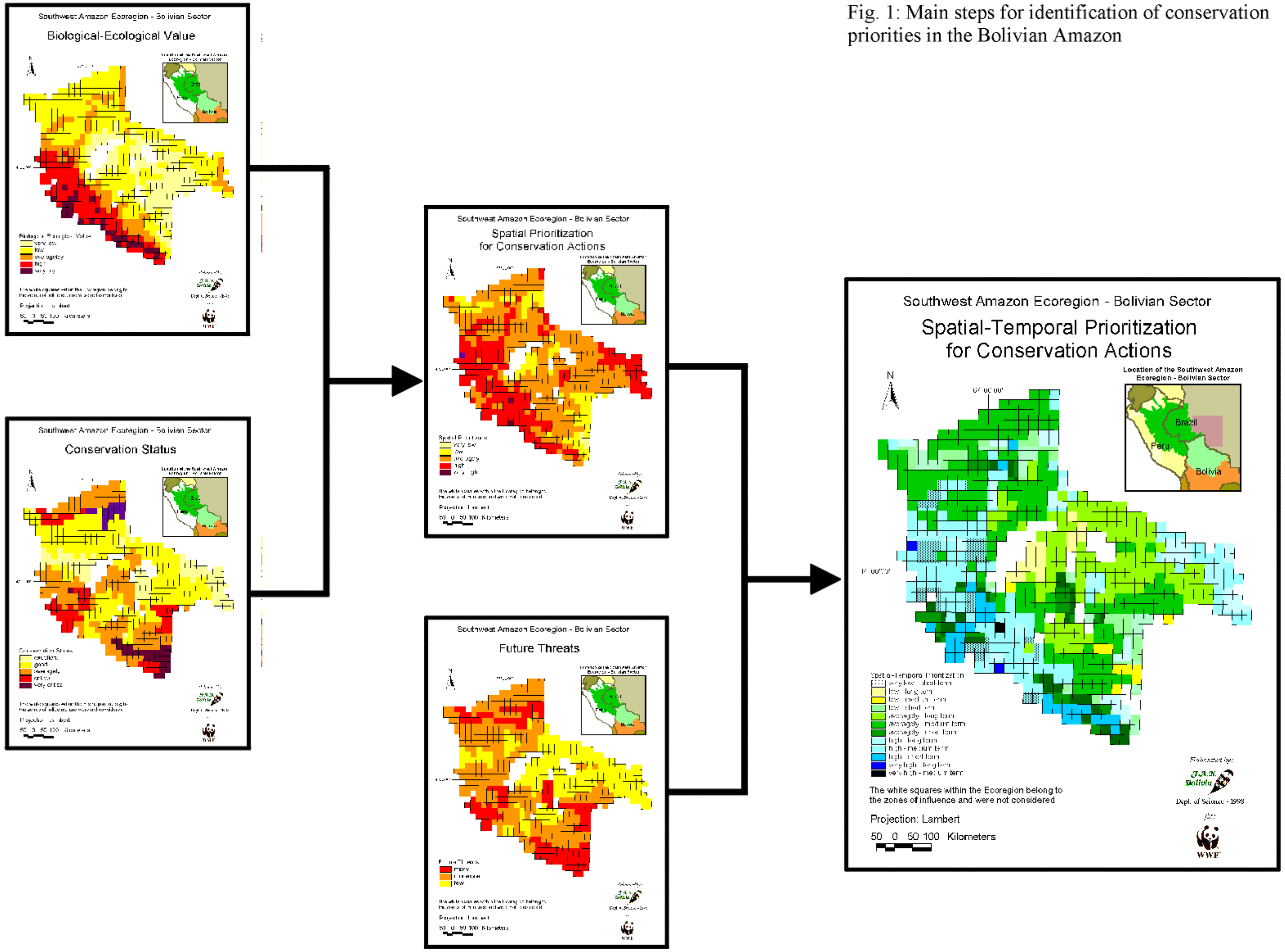
The evaluation of biological criteria was not only performed at the level of taxonomic groups, but also considered biological and ecological functions and processes. The analysis was performed by giving a relative value (very high, high, medium, low, very low) to each 15-minute square. This value was based on its biodiversity sub-value (often composed of several basis-values), which was determined by analyzing the biological and ecological characteristics of the area within the square.

The first step of the biological spatial analysis was to analyze, extrapolate and map the patterns of diversity of selected indicator groups (amphibians, birds, fishes, mammals, reptiles and vascular plants) as basis values. There are many spatial gaps in the information on species richness and endemism in the Bolivian Amazon. Based on published and unpublished data (the extensive biological bibliography with almost 200 references that were considered is not cited in this paper) and consultations with specialists in the different indicator groups, distribution patterns were extrapolated using topographic and vegetation maps. If several areas within, for example, the sub-Andean forests with very high precipitation were known to bear a very high species richness, then the same “very high” value was applied to all grid cells belonging spatially to this formation. While this method may risk overestimating the extent of biologically important areas, this is considered preferable to neglecting special areas. Indicator taxa were chosen which allow a preliminary extrapolation based upon a minimum set of information on their diversity patterns. Thus, it was impossible to include data on invertebrates. The averages of the different basis-values were taken as sub-values (*endemism*, *species richness*). The sub-value *habitat diversity* was determined by calculating two basis values. Those values, considered to be fairly objective proxy indicators, are within-grid cell *topographical variation* (counting one point for each change of 100 m elevation within one square; analysis based on the IGM 1993 physical map of 1:1,000,000) and *large-scale vegetation types* per square (counting one point for each type encountered; analysis based on Ribera et al. 1994, 1:1,500,000) and converting the sums in the 5-scale valuation (examples: very high = >7: area with three large-scale vegetation types and 4 altitudinal belts of 100 m; very low = 1: area with one vegetation type within one altitudinal belt).

The ecological sub-values (such as *importance for biogeographical processes*) reflect preliminary and rough assumptions. Only two categories were allowed for the basis values (less important = 0 or more important = 1). The chosen sub-values are: 1) *Importance for biogeographical and evolutionary processes* (with the basis values: a) *area of probable importance for seasonal migration of existing species*; b) *area of probable importance for species migration in times of climatic change*; c) *area of probable importance for speciation*; d) *biogeographically important area for belonging to an ecoton zone*); 2) *Ecological functions and processes* (with the basis values: a) *river protection*; b) *protection of high watersheds*; c) *carbon storage*; d) *importance for regional climate* such as generation of precipitation, water cycle etc.).

The totals for the grid map of biological-ecological values (see Fig. 1) was obtained by summing all the above-mentioned sub-values: *endemism* + *species richness* + *habitat* *diversity + importance for biogeographical and evolutionary processes + ecological functions*.

Fig. 1: Main steps for identification of conservation priorities in the Bolivian Amazon



2.3. Socioeconomic evaluation

Socioeconomic information, based on census data or on analysis of development projects, is required for the analysis of conservation status, future threats, limitations and opportunities for conservation. These data are much more abundant and solid than the biological data. It is a challenge to use the variety of socioeconomic criteria such as population density, existing roads, forest concessions, indigenous territories, etc. as proxy indicators for the conservation status analysis. Several basis values make up the three sub-values of conservation status: 1) *integrity of habitat* (mainly status, dynamics and distribution of deforestation), 2) *perturbation* (degradation, but not clearing, of the forests) and 3) *contamination*. Certain basis values contributed to several sub-values, resulting in a higher importance for some (e.g. access infrastructure augments both deforestation and perturbation). The most important step was to interpret how a given socioeconomic situation might affect conservation; e.g. it was assumed that poverty is a limitation to conservation because people with more urgent needs are not very eager to learn about ecoregional conservation; or a high percentage of indigenous population probably means less perturbation of the forests and an opportunity for the implementation of sustainable use programs.

A related task was to define appropriate criteria for the conservation analysis and convert the diverse data available for different administrative-political areas (e.g. provinces, municipalities, municipality sections) into a single spatial format that, in a following step, would permit integration with the biological data. For this purpose 82 *Conservation Units* were defined as regions with homogeneous socioeconomic and legal conditions to which a uniform conservation strategy would be applied. These conditions included, among others, land use rights (e.g. protected areas, indigenous territories, forest concessions), population density, urban centers, and current land use (e.g. colonization, agriculture, cattle ranching).

Afterwards, a numeric value for twenty-three conservation-oriented criteria was attributed to each conservation unit (normally from 1 to 5, with the highest value for the most critical dimension for biodiversity conservation; e.g. in the case of the criterion *Population density*, more than 10 inhabitants/km^2 = 5, 3-10 i/km^2 = 4, 1-3 i/km^2 = 2, 0,5-1 i/km^2 = 2, 0-0,5 i/km^2 = 1). Adding certain selected basis values of the twenty-three criteria, the three sub-values of the value of conservation status were calculated. In the same way, opportunities and limitations for conservation were obtained. Table 1 indicates which basis value contributed to each (sub-) value. The resulting sums of the sub-values were grouped numerically in five ranges (from “very high” to “very low”), added to the conservation status value and the resulting sums again grouped in five ranges. In the case of the analysis of opportunities and limitations, the five defined categories were named “many opportunities” (5), “more opportunities than limitations” (4), “opportunities and limitations balanced” (3), “more limitations than opportunities” (2) and “many limitations” (1).

Table. 1: Basis values used for the calculation of the value of conservation status and opportunities/limitations for conservation (and sources)

Basis values	**Conservation Status – Sub-value** ***Integrity of Habitats***	**Conservation Status – Sub-value** *Perturbation*	Conservation Status – **Sub-value** ***Contamination***	**Opportunities and limitations**
Human settlements (INE 1993)		+	+	
Colonization (INE 1993)	+	+		
Percentage of indigenous population (CPTI 1998)		+		
Access by rivers (maps, CPTI 1998, NRECA 1998, OTRA 1998, ZONISIG 1998)		+		
Access by roads (OTRA 1998, CPTI 198, ZONISIG 1998)	+	+		
Population density (INE 1993)		+		
Population growth between 1976-1992 (INE 1997[a])		+		
Annual im- and emigration (INE 1997[b])		+		
Human poverty (following the poverty map of Ministerio de Desarrollo Humano 1995)				+
Traditional / informal / illegal timber exploitation (Camara Nacional Forestal 1996, BOLFOR 1998, DGB 1998, CPTI 1998, OTRA 1998)		+		
Commercial timber extraction within concessions (BOLFOR 1998, DGB 1998, CPTI 1998, OTRA 1998)		+		
Extensive cattle ranching and agriculture in forests (Pacheco 1998)	+	+	+	
Migratory agriculture (extrapolated from information on agriculture in colonized areas)	+	+	+	
Extraction of palm hearts (mainly based on distribution map of the species and proper data)		+		
Extraction of other non-timber products (rubber, brazil nut; mainly based on distribution map of the species and proper data)		+		
Mining activities (BOLFOR 1998, CPTI 1998)		+	+	
Oil industry activities (map of concessions; Andina S.A. 1998)		+	+	
Real use restrictions (maps of protected areas and information on state of their implementation, indigenous territories, forest concessions etc.; BOLFOR 1998, DGB 1998, CPTI 1998, OTRA 1998)				+
Coverage of conservation and sustainable use projects (interviews and unpublished documents of different development institutions)				+
Institutional capacity of civil society (interviews and unpublished documents)				+
Institutional and legal conflicts (extrapolation based on GIS-overlay of maps on protected areas, indigenous territories, concessions etc., and unpublished information on institutional conflicts)				+

Deforestation rate (1985-1990) (CUMAT 1992)	+			+
Deforested area until 1992 (Ministerio de Desarrollo Sostenible y Medio Ambiente 1995)	+			+

Finally, the values of the *Conservation Units* (CUs) were converted into the GIS grid system used for the biological valuation. For example, if a square was completely covered by a CU with the value 5, the square received the same value. If a square was covered by two CUs it obtained the value of the CU which covered at least 50% of the square; if a square was covered by more than 2 CUs an average was calculated, avoiding fractions; squares located on the border of the study region obtained the value of the CU which covered the square at least partially.

Future threats: In order to calculate potential threats, future conversion, perturbation, and contamination were estimated and extrapolated as “few” / “moderate” / “many”. The sums of these three sub-values were then grouped into three value ranges. The estimates were based primarily on current conservation status, demographic tendencies, land use categories according to official land use plans and ongoing project activities (e.g. road construction). Obviously, it is impossible to foresee dramatic threats arising during the execution of large-scale projects such as pipeline construction.

2.4. Integration of biological and socioeconomic data and identification of spatial priorities

Spatial overlay of the biological-ecological value and the conservation status in the GIS permitted prioritization of areas to conserve. The intersection was achieved by adding the biological-ecological value (1-5) of each grid cell with the value of conservation status (1-5). The sums were grouped in priority ranges: 2 = very low, 3-4 = low, 5-6 = medium, 7-8 = high, 9-10 = very high. Of course, it is debatable whether an area already classified as very critically endangered (5) still merits a high conservation priority if its biodiversity has already been lost. However, in the case of the Bolivian Amazon, we believe that even within critically endangered areas, there still exist some very valuable patches of natural habitat that require urgent conservation activities. Of course, any discussion of these areas must consider the grid resolution used for the evaluation.

Spatial-temporal priorities: Taking into account the analysis of future threats, the spatial prioritization is enhanced by a time dimension. Overlaying the map of spatial priorities with future threats leads to suggestions on the necessary spatial-temporal priorities. In this case the values of the grids were not simply added and numerically grouped but literally combined: many future threats in a square raise the previously defined spatial conservation priority to the category “short-term”; moderate future threats lead to “medium term”; few future threats lead to “long-term”. The result is a scale of 15 categories, ranging from “very high short-term priority” (for very valuable and very critically endangered areas with many expected future threats) to “low long-term priority” (for areas with a low biological-ecological value which are well conserved and with a low probability of suffering from future threats). Fig. 1 shows the mainsteps of the prioritization process including the map of spatial-temporal priorities.

Action viability-priority analysis: Finally, adding the spatial-temporal priority values (grouped into 5 ranges) to the values calculated for opportunities and limitations suggests some preliminary ideas about how and where conservation funding agencies might best allocate their resources in different areas. The suggested action values are: 2 = wait before implementing any action (in areas with low priorities and many limitations), 3-4 = eliminate limitations /establish opportunities, 5-6 = eliminate limitations /establish opportunities and simultaneously implement concrete measures, 7-8 = implement concrete measures considering the existing limitations, 9-10 = implement concrete measures making use of the existing (institutional) opportunities and capacities.

3. Results and discussion

In the context of this paper it is impossible to present all the results which were obtained by the application of the methodology presented above. However, a short overview of the most important are presented.

3.1. Biological evaluation

The main challenge of the biological evaluation was to avoid the negative impact resulting from insufficient knowledge of biodiversity patterns. Perhaps there will be more complete databases in the future, but perhaps not, especially for areas which may be destroyed or degraded without having being studied. Therefore, best use must be made of the scarce existing information now, taking into account even “gray” or unpublished bibliographies and extrapolating assumptions of experts on biodiversity patterns. The window for establishing biologically important areas for protection will last about 5 to 10 more years. The question is whether to base conservation decisions on incomplete scientific data or none.

Although the data are scant, some general patterns emerge: in all of the analyzed groups, endemism is clearly concentrated in the southwest (pre-Andean and sub-Andean forests). Here, the patterns of alpha-diversity are more variable and indicate that the most diverse regions are found within the pre-Andean, sub-Andean and tall evergreen forests of northern Bolivia. In order to represent adequately the existing biodiversity in the lowlands, about 15-20% should be conserved. In the (sub-) Andean regions – due to very high beta-diversity - up to 70% might be necessary.

3.2. Socioeconomic evaluation

The result of the conservation status analysis (see Fig. 1) is extremely positive, considering that more than 54% of the study region has at least a good status, and 85% has at least an average status: 14.2% of the Bolivian Amazon is classified as having a "very good" conservation status while 40.4% has a "good" status, 30.3% a status of "average", 8.4% a "critical" status, and only 6.7% has a status evaluated as "very critical." Large blocks with at least “good” conservation status are found mainly in the eastern lowlands. The map of future threats (see Fig. 1) is similar to the map of conservation status, but varies in certain key areas due to projected tendencies in future development. The analysis indicates that human development pressure will increase especially in the north of Bolivia; road construction projects are identified as key threats; e.g. the Chiva to Ixiamas road, crossing the Manuripi-Heath reserve, endangers the most intact stretch of forest remaining in Bolivia. Many “hot spots” of biodiversity threats are found in the pre-Andean and sub-Andean forests, which have been identified as the most biologically valuable of the study area. Sixteen percent of the entire Bolivian Amazon is found to have a high level of future threats and 50% a medium level, while 34% is predicted to suffer only low levels of threats to biodiversity in the next years.

The opportunities for conservation are more favorable in areas with a poor conservation status; this is due to the advance of human development in areas of heavy colonization and to the involvement of a multitude of institutions with projects focused on natural resource management. On the other hand, especially in the northern Bolivian Amazon, suffers from a preponderance of limitations and few bases upon which to build conservation activities. It becomes apparent that it is extremely important in the short term to invest in institutional development and reinforcement in order to create and foster local organizations involved in promoting conservation efforts.

3.3. Integration of biological and socioeconomic data and identification of priorities

The areas spatially prioritized (see Fig. 1) correspond mainly to sub-Andean forests (and adjacent montane Yungas rain forests), pre-Andean forests (especially due to a complex mixture of high diversity and endemism and somewhat critical conservation status) and connected areas in the northern lowlands of Bolivia along the Beni and Madre de Dios rivers. These riverine areas obtained higher priority values primarily due to the high valuation of river protection and fish diversity. In addition, there are several smaller, high priority areas, such as the upper Río Itenez region around the Noel Kempff Mercado National Park, where biogeographical confluence and azonal habitat diversity (e.g. pre-Cambrian table mountain) have create a biologically important area, which is still very well preserved.

In terms of temporal priorities, four large blocks were identified in which preferential actions should be implemented in order to develop a network of conservation areas with connecting regions: 1. the sub- and pre-Andean Amboró-Madidi block (including the Amboró, Carrasco, Isiboro-Securé, Estación Biológica del Beni, Pilón Lajas, Madidi protected areas), 2. the Manuripi-Iturralde block in the region of the northern high lowland rain forests south of the road joining Cobija and Puerto Rico (including the Manuripi-Heath national reserve), 3. the Abuna-Madera block in the extreme northeast of Bolivia (including the Federico Román reserve), and 4. the Itenez-Mamoré block (e.g. including the Noel Kempff National Park and the Ríos Blanco y Negro, Kenneth Lee, Iténez, Pedro Ignacio Muiba reserves). Especially urgent activities are required in the pre- and sub-Andean region and in the north of Bolivia.

Of course, the proposed automatically calculated prioritization is not the only basis for decision making; maps of sub-themes, of basic or sub-values, or of biodiversity patterns – as well as information on density of scientific studies / biological inventories – also suggest ideas for conservation planning.

A key conclusion from the integration of biological and socioeconomic data is very positive: All the blocks which were identified as having a conservation status of “good“ or “very good“ are qualified as biologically relevant in that they represent the current biodiversity and are viable in terms of maintaining biological and ecological processes. Thus, if one takes advantage of the opportunities for conservation within the prioritized areas, it is still possible to design an expansive and connected network of protected areas.

We are pleased to announce that as a first and very immediate result of this prioritization exercise, conservation projects are now being implemented just one year following the conclusion of the study. In the most prioritized area of sub- and pre-Andean forests (Amboró-Madidi block), which represents a region of high importance as a latitudinal and altitudinal bio-corridor, WWF Bolivia PO with funding from USAID, and through different Bolivian actors (including the National Service for Protected Areas - SERNAP and local NGOs), is starting to coordinate activities of bio-corridor management. Additionally, the Manuripi-Heath reserve is institutionally supported.

Acknowledgements

This publication is based on data prepared with funding from WWF-grant QZ14 awarded to the *Fundación Amigos de la Naturaleza Noel Kempff* (F.A.N.). The participation of the first author was supported by CIM, Germany. We thank Patricia Caffrey and Katherine Pierront, WWF Bolivia PO, for guidance and help. We appreciate the very valuable support of dozens of Bolivian institutions and international projects providing published and unpublished information. Also we are indebted to a group of zoologists who helped us with the biodiversity maps: Susan Davis, Jörn Köhler, Julieta Ledesma, Stefan Lötters, Steffen Reichle. Lisette Correa supported the GIS work.

References

Andina S.A., (1998). Unpublished data.

BOLFOR - Proyecto de Manejo Forestal Bolivia, (1998).– Unpublished data.

Cámara Nacional Forestal, (1996). Estadísticas de aprovechamiento, exportación y comercialización nacional de productos forestales – Gestión 1995. Santa Cruz, Bolivia.

CPTI, (1998). Centro de Planificación Territorial Indígena. Unpublished data.

CUMAT (Capacidad de Uso Mayor de la Tierra), (1992). Desbosque de la Amazonía boliviana. La Paz, Bolivia.

DGB (Dirección General de Biodiversidad), (1998). Unpublished data.

Dinerstein, E., D.M. Olson, D.J. Graham, A.L. Webster, S.A. Pimm, M.P. Bookbinder & G. Ledec, (1995). A conservation assessment of the terrestrial ecoregions of Latin America an the Caribbean. World Bank / WWF, Washington D.C.

Ibisch, P.L., (1998). Bolivia is a megadiversity country and a developing country. In: Barthlott, W. & M. Winiger (eds.): Biodiversity - a challenge for development research and policy. Springer-Verlag, Berlin, 213-241.

IGM (Instituto Geográfico Militar), (1993).: Mapa Físico de Bolivia. 1: 1.000.000. La Paz, Bolivia.

INE (Instituto Nacional de Estadística), (1993). Resultados finales del Censo Nacional de Población y Vivienda de 1992. La Paz, Bolivia.

INE (1997[a]). Características demográficas de la población en Bolivia. La Paz, Bolivia

INE 1997[b]). Migraciones de la población económicamente activa. La Paz, Bolivia.

The International Bank for Reconstruction and Development / World Bank (1994) World development report 1994. Infrastructure for development. Oxford Univ.Press, Oxford.

Ministerio de Desarrollo Humano, (1995). Mapa de Pobreza: una guía para la acción social. 2º ed. La Paz, Bolivia.

Ministerio de Desarrollo Sostenible y Medio Ambiente, (1995). Mapa Forestal de Bolivia. 1:1.000.000. La Paz, Bolivia.

NRECA (National Rural Electric Cooperative Association), (1998). Unpublished data.

Olson, D. M. & E. Dinerstein, (1998). The global 200: a representation approach to conserving the earth´s most biologically valuable ecoregions. In: The Journal of the Society of Conservation Biology 12 (3): 502-515.

OTRA (Programa para el Ordenamiento Territorial de la Región Amazónica, en los Departamentos de Beni, Cochabamba y La Paz), 1998. Unpublished data.

Pacheco, B.P., (1998). Estilos de desarrollo, deforestación y degradación de los bosques en tierras bajas de Bolivia. La Paz, Bolivia.

Ribera, M.O., M. Liberman, S.G. Beck & M. Moraes, (1994). Mapa de vegetación de Bolivia. 1: 1.000.000. La Paz, Bolivia.

WWF, (1998). The global 200. A blueprint for saving life on earth. Washington.

ZONISIG (Proyecto Zonificación Agroecológica y Establecimiento de una Base de Datos y Red de Sistemas de Información Geográfica en Bolivia), (1998). Unpublished data.