Lista de Mamíferos Registrados Durante el RAP Alto Cuyuní 2008, en Tres Áreas Focales en río Uey, Cuenca Alta del río Cuyuní, Estado Bolívar, Venezuela

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Executive Summary

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INTRODUCTION

The AquaRAP Program

The Rapid Assessment of Freshwater Aquatic Ecosystems Program (AquaRAP) was created in 1990 by Conservation International (CI) with the objective of rapidly collecting the biological information necessary to accelerate conservation actions and protection of biodiversity. Groups of researchers, international as well as local, with specialty in fresh water and terrestrial biology undertake field work for 2-4 weeks) with the objective of evaluating said biodiversity. These teams provide recommendations for conservation based on the biological diversity of the area, the level of endemism, the uniqueness of the ecosystems and the risk of extinction for some species at the national to the global scale.

The scientists that make up the RAP teams evaluate the diversity of the groups of organisms selected as indicators, analyzing this information together with social, environmental and other appropriate data sources, with the objective of contributing realistic and practical recommendations for institutions and individuals responsible for making decisions. Within the Rapid Assessment Program (RAP), AquaRAP was created in association with the Chicago Field Museum as a multinational and multidisciplinary program, directed at identifying priorities for conservation and opportunities for sustainable management of freshwater ecosystems in Latin America. The mission of AquaRAP is to evaluate the biological diversity and its conservation in tropical freshwater ecosystems through undertaking rapid inventories. AquaRAP teams have evaluated the aquatic biodiversity of different watersheds in Bolivia, Brasil, Paraguay, Peru, Ecuador, Venezuela, Guyana and recently, Suriname. Moreover, CI's AquaRAP Program has undertaken surveys of aquatic biodiversity in Africa (Okavango Delta, Bostwana, 2000) and Central America (Petén, Guatemala, 1999).

The results of AquaRAP have served as scientific support for the establishment of national parks in Bolivia and Peru, providing the biological baseline information of little explored tropical ecosystems. Furthermore, the AquaRAP program has identified threats and proposed recommendations for the conservation of freshwater and estuary ecosystems. The results of AquaRAP surveys are practically immediately available for all parties interested in conservation planning.

Specific objectives of the 2008 Upper Cuyuní RAP survey

- Inventory species of mammals, birds, reptiles, amphibians, fishes, crustaceans, mollusks and other aquatic invertebrates (especially insects) and riparian plants.
- Describe the vegetation types present in the sampling areas.
- Determine the physicochemical parameters for water of the Cuyuní and Uey rivers and their tributaries, to determine the level of perturbation of the rivers, river branches, and streams; and generate a baseline of geochemical information for the water that is needed for the conservation and management of the basin.

- Produce a list of endemic species and/or species with restricted distribution in the area of study.
- Determine the most important species for conservation plans (threatened, endangered, etc.) and/or sustainable use.
- Identify the habitats or areas of special interest (high diversity, high endemic species density, etc.) present in the area of study.
- Identify present and potential threats in the area.
- Collect information and evaluate the level of mercury contamination in the aquatic organisms (fishes and invertebrates), water, and sediments in the upper basin of the Cuyuní River.
- Generate baseline information for management plans for the area and establish recommendations for conservation and biodiversity monitoring plans.

BACKGROUND

Venezuela is in the top ten countries with the most biodiversity on the planet. It has ten bioregions, many of which are characteristic of or unique to the northern part of the South American continent. The region to the south of the Orinoco River alone houses more than half of Venezuela's biodiversity. This is due in large measure to the geological history of the Guayana region, the elevated species richness of the Amazon region, and individual contributions from unique ecosystems found only in this zone.

The area traversed by the Cuyuní River is part of the eastern sector of the system of foothills of the Guayana Shield and, in general, the vegetation has been classified as high semi-deciduous ombrophilous (wet) forest and foothill, ombrophilous evergreen forest, with high floral diversity due to the large areas dominated almost exclusively by species in the genus *Mora*. The Cuyuní River is located in the phyto-geographic province of "Eastern Guyana", with more than 15,000 species of vascular plants, a high level of endemism (four families and 140 genera endemic) and containing almost all the vegetation formations characteristic of the Guayana region.

From the hydro-geographic point of view, the Cuyuní River Basin is really a sub-basin of the Essequibo River, which originates in Guyana. The basin occupies a surface area of approximately 50,000 km^2, of which 38,000 km^2 are in Venezuela, the rest in Guyana (Mago 1970). The Cuyuní River has a length of 750 km, with the Venezuelan part denominated as the Upper Cuyuní due to its position within the drainage network (Lasso *et al*. 2003). The headwaters of the Cuyuní River are located in the Serranía de Lema (Lema Mountain) and the Cerro Venamo (Venamo Mountain) between 1300 and 1500 m above sea level. The waters are clear and black, which makes the region of great interest because it increases the diversity of aquatic species and heterogeneity of the habitats. Yet, despite this diversity, the geopolitical importance as a frontier zone, and presence of some of the most important exploration for gold and diamonds of all Venezuela, the basin has received little attention from a biological viewpoint. This lack of study and monitoring has allowed a profound alternation of the surrounding forests, as well as effects on the quality of water due to gold mining, which has not been adequately evaluated or actions taken to correct the problems. The isolation of the basin hydrologically has led to the existence of unique species (endemics) in this region, especially among the aquatic fauna (fishes and crustaceans) despite historical connections with the Orinoco River and current connections with the Amazon River basin, which are reflected in a shared biodiversity within much of the flora and fauna.

The Cuyuní River is one of the most important water courses in Venezuela in terms of fish species richness, which is about 20% of the fish fauna known from continental Venezuela. Nevertheless, there are still gaps in our knowledge of the ichthyofauna of this area, as well as for aquatic macroinvertebrates, many of which are endemic and biogeographically important. The herpetofauna is extremely interesting, with at least 30 species of amphibians and 40 species of reptiles recorded, just from along the stretch of highway between El Dorado and La Escalera in Lema. These findings are notable in terms of richness, they are even more interesting because before that study, only six amphibian and three reptile species had been recorded for that zone. The Cuyuní River Basin is of interest for the conservation and study of birds (IBA areas), especially in Imataca Forest Reserve and Canaima National Park. In addition to its high bird diversity and endemism, this region harbors many threatened bird species, such as the Harpy Eagle (*Harpia harpija*). The Serranía de Lema is one of the most famous areas in the world for observing many species of birds, many of them endemic or migratory. The mammals of the Cuyuní-Essequibo system represent a diverse group in comparison to the vertebrates in other parts of the Guayana Shield, especially in forests. This region contains many species of monkeys, marsupials, terrestrial and arboreal rodents, high bat diversity, and many of the Neotropical large mammals, including tapirs, pacas, deer, and armadillos (all of which are consumed by the local people) and large cats including jaguar and puma, among others. The small mammals play an especially important ecological role in the Guayanese forests, acting as seed dispersers, pollinators, and control of many pest insects. There are several threatened mammal species in this area, including the giant armadillo and large cats, as well as a marsupial only recently described and endemic to the forests of the Serranía de Lema, *Monodelphis reigi*.

Based on the recommendations of the group of experts of the Guiana Shield Initiative (Consenso 2002), IUCN, UNDP and Conservation International, the upper part of the Cuyuní River Basin was identified as a priority area for conservation, warranting further research as well as development of monitoring and conservation plans. Following the recommendations of this international group, the First and Second Workshops of National Experts for the Definition of the Guayana Corridor in Venezuela were organized by CI-Venezuela and BioHabitat A.C. in 2005 and 2007, respectively. At these workshops, the importance of this region from a biological viewpoint was confirmed and planning began for a rapid biodiversity assessment (RAP)

to collect baseline data for the design of biodiversity conservation and monitoring plans.

For all these reasons, and taking into consideration the high threats to this region, Conservation International Venezuela (CI), Fundación La Salle de Ciencias Naturales (FLSCN) and Gold Reserve de Venezuela C.A. – Compañía Aurífera Brisas del Cuyuní C.A., joined efforts to conduct this Rapid Biodiversity Assessment (RAP) in the Cuyuní River Basin. The goal of the RAP survey was to collect the most information about the biodiversity of the region in a short time period, while maintaining a high scientific level and quality. To achieve this, aquatic survey techniques (AquaRAP) were integrated with techniques for terrestrial biodiversity, with team of scientific experts in each taxonomic group, including flora and vegetation, aquatic invertebrates, fishes, amphibians and reptiles, birds, mammals, and aquatic geochemistry. Complementing this study was a characterization of the levels of mercury in fishes, aquatic invertebrates, water and sediments in the upper Cuyuní River Basin; as well as a synthesis of the mammals of Cuyuní River Basin and herpetofauna of the Sierra de Lema, since it is an area of special interest for diversity and endemism of amphibians and reptiles.

The results from this RAP survey notably increase our knowledge of the diversity and biogeography of the zone, and the Guayana region. It also contributes baseline information for future biological and social studies, proposals for conservation and sustainable use plans, for both individual species and ecosystems.

Between January 18-31, 2008, the RAP team surveyed the Upper Cuyuní River Basin, dividing the study area into five focal areas:

- Focal Area 1 – Lower Uey River, from the confluence of the Cuyuní and Uey rivers (06° 06'11,5" N – 61° 30'34,3" W), to a stream located upstream from the Uey River (Stream 2, tributary of the Las Malocas Stream, 06° 04'12" N – 61° 28'08,8" W), at an average elevation of 123 m a.s.l.;

- Focal Area 2 – Upper Cuyuní River, sector between the confluence of the Cuyuní and Uey rivers and a tributary stream off the left bank of the Junín River (06° 05'44" N – 61° 33'20" W), 120 m a.s.l.;

- Focal Area 3 – Lower Cuyuní River, located between the confluence of the Cuyuní and Uey rivers and principal channel of the Cuyuní River located after its confluence with the Quebrada Amarilla (06° 11'21" N – 61° 30'21" W, 115 m a.s.l.);

- Focal Area 4 – Upper Uey River, located at the headwaters of the Uey River in the Sierra de Lema, including a small section of the waterfalls of the Uey River (05° 57' 29,8" N – 61° 30' 15,2" W) at an elevation of 586 m a.s.l., until the principal channel of the Uey above the waterfalls (06° 57' 16,2" N – 61° 30' 13,6" W) at 600 m a.s.l; and

- Focal Area 5 – Middle Uey River, in the foothills of the Uey River and the spurs of the Sierra de Lema at 06° 02' 23,5" N – 61° 30' 26,4" at an elevation of 135 m a.s.l. until the principal channel of the upper waters of the Uey River (subsidiary branch) (06° 01' 59,6" N – 61° 30' 49,6" W, 170 m a.s.l.).

RELEVANT RESULTS FOR CONSERVATION-RELATED CONSIDERATIONS

Criteria for Conservation
Primary Criteria

Heterogeneity and uniqueness of the habitat

In general, the entire study area is totally covered with mature forest, with canopy heights of over 50 m and dense coverage common, particularly in forests dominated by mora (*Mora* sp.). In spite of this apparent homogeneity of vegetation, a substantial portion of the forest has been impacted by small-scale gold mining and selective logging, especially along the Cuyuní River where there is much secondary forest. In these areas there is "tierra firme" forest which covers more area than the flooded forest. The middle sub-basin of the Uey River is dominated by tall and medium forests, which are more diverse than forests of the Cuyuní River Basin, while the upper sub-basin of the Uey River, in the foothills of the Sierra de Lema mountain, features medium height forests whose floral composition is related to that of the Gran Sabana and the tepui (table-top mountain) environment of low altitude and are different than forests found at lower altitude.

In the upper and middle basin of the Cuyuní River, both in the principal channel of the river and in the tributary streams, the water was slightly acidic to neutral; the levels of turbidity, suspended and dissolved solids, and conductivity were relatively low, which is typical of rivers with black and clear water that flow from the Guayana Shield. Nevertheless, some streams had elevated concentrations of suspended solids resulting from intense mining activities in the area. In the sub-basin of the Uey River, a greater number of sampling stations had higher levels of dissolved organic carbon. We also found a positive correlation between the dissolved elements Fe, Al, and Cu and dissolved organic carbon, suggesting that the solubility of these elements was promoted by the concentration of humic substances in the solution. Waters coming from zones that had been highly impacted by mining activity showed lower levels of dissolved organic carbon, which may be associated with the impact of mining activities on superficial horizons of the soil.

The differences in geo-morphological characteristics of the Cuyuní, Uey and their tributaries, as well as the waterfalls and rapids which act as barriers to dispersion of species, determine the distribution and diversity of the aquatic fauna, including both the vertebrates and macroinvertebrates. This is seen in the assemblies or associations of fishes in the Uey River, which are distributed along an altitudinal gradient from less to higher complexity from upper waters to lower waters. This also occurs within the herpetofauna, especially the amphibians of the middle and upper Uey River along the slopes of the Serranía de Lema, which is a typical Guayanese fauna, including taxa endemic to the eastern Venezuelan Guayana region (Canaima National Park).

Present level of threat

In general, the Cuyuní River Basin is facing a high level of threat, especially in the lower and middle portions, from gold mining. The mercury levels in the sediment, water and aquatic biota are dangerously high. Additionally, the high values of HQ (Hazard Quotient), which measures the risk of ingesting mercury, suggests that there is a serious risk to the health of the local human population from eating fishes from these rivers. The sub-basin of the Uey River, especially its headwaters in the Serranía de Lema remain in almost pristine condition, with a relatively low level of threat since it is legally protected within Cainaima National Park above 500 m elevation. However, during the RAP survey, three illegal mining camps were observed on the Uey River, with is an alarming situation. The elevated level of Hg detected in fishes coming from the headwaters of the Uey River (a tributary of the Cuyuní River located in the Sierra de Lema), indicates that there is a transport of metal from the mining areas into zones that are apparently pristine.

Potential and Opportunities for Conservation

There are opportunities for conservation activities in the region. Although the Cuyuní River and some of its tributary streams have already been notably disturbed, there is still the opportunity to preserve environments that remain relatively unaltered, such as the Uey River. The Uey River system of black water is unique in the Cuyuní River Basin, and maintains a high level of species diversity and of species endemic to the eastern Venezuelan Guayana region. The impact of mining in the sub-basin of the Uey River, especially in the middle and upper sections, is still isolated and manageable, even though three illegal mining camps were observed and may have re-located. Thus we highly recommend the protection of the sub-basin of the Uey River, especially since conservation of the entire Cuyuní River basin has fewer opportunities and would not be realistic. Canaima National Park, whose summit includes the headwaters of the Uey River, could be extended to include the lower sections of the Uey River in order to protect the middle and lower basin of this river. The presence of Gold Reserve de Venezuela C.A.- Compañía Aurífera Brisas del Cuyuní C.A. in the area provides the opportunity for a positive alliance for conservation through its collaborative work with local communities and governmental institutions.

Level of Fragility

The upper Cuyuní River Basin will likely continue to be affected directly by mining activities in the region and by the associated impacts of these activities (logging, fire, deforestation, increased sedimentation and changes in the physical-chemical composition of the water, among others), with evident impacts (loss of biodiversity is the most evident). Since this river system is an oligotrophic system (low nutrient and low productivity), it is less capable of ameliorating the chemical and physical changes in the water, as well as the subsequent changes in vegetation and fauna associated with these water changes. The mining activity in the area for the last few decades has already used up and washed the river bed of the streams and rivers in a very notable manner, leaving conditions practically irreversible in many places.

Other significant biological factors (ecological processes)

The upper Cuyuní River Basin contains a mix of water types (black and clear) that is typical of the Guayana Shield and creates conditions for high biodiversity and uniqueness of the aquatic fauna. The Cuyuní River is a dispersal (migration) corridor for several species of commercial fishes, and is the only habitat in the country for species of striped catfish (*Pseudoplatystoma fasciatum*) and pavón (*Cichla ocellaris*). These two species are the most important in terms of commercial value and human use, although there are many additional important species- not only fishes- that are endemic and extend geographically into this region. Toward the upper part of the basin there is also "aimara" (*Hoplias macrophthalmus*). This region is also a stop-over for two species of migratory birds from North America. The upper Cuyuní River Basin is located within the Imataca Forest Reserve, a region identified by Birdlife International an Important Bird Area (IBA) due to its diversity and ecological value. Lastly, many species of mammals and birds of "cinegetic" interest are found there in elevated abundance. This region is thus an important reserve for the reproduction and conservation of these species, which are threatened and have had their populations notably reduced in the lower parts of the basin.

Secondary Criteria

Endemism

Since the upper Cuyuní River Basin is the only part of the Essequibo basin that is within Venezuela, the level of aquatic endemism is high. In addition, the upper parts of the basin, especially the slopes and the cliffs of the Serranía de Lema, where the headwaters of the Uey River, contain a high number of species with limited dispersal, including macroinvertebrates, fishes and amphibians. Also in these areas there are flora and fauna exclusive to the tepui environments of the western Guayana Shield, which is only found in this region of Venezuela.

Productivity

One of the most evident elements of the rivers of the Cuyuní River Basin is its low productivity, even for an oligotrophic system, characteristic of black and clear waters. All the rivers within this basin drain from rainforest and poor soils- sandy and granite- and, in contrast to the white waters of the Orinoco Basin, do not have important commercial fisheries. The presence of large individuals of many fish species in the Cuyuní River Basin is due to the absence of commercial fisheries as well as a subsistence fishery. Also, there seems to be a high biomass of large mammals of cinegetic interest, due apparently to either low hunting pressure or hunting that has not reached the threshold of the reduced population. It seems that it is more convenient for the mining camps to import all their necessary food from the nearby communities instead of spending time fishing and hunting.

Diversity

The low productivity is compensated by a relatively high diversity. One hundred and twenty-five (125) species of

fishes were documented during this survey, with a theoretical estimate of 133-150 species, which is about 65% of the fished known from the entire basin. The species richness of terrestrial fauna- mammals, amphibians, and reptiles, is similar to other areas of the Venezuelan Guayana. Recognizing that this region harbors more than half of the upper Cuyuní River Basin contains a significant portion of the country's biodiversity. Within this diversity are species unique to the Serranía de Lema and the upper Cuyuní River Basin, as well as Amazonian species which have a more northern distribution within the area of study. Furthermore, the avifauna of the Imataca Forest Reserve is one of the most diverse in the Americas and has been identified as an Important Bird Area (IBA).

Significance for humans

Historically, within the upper Cuyuní River Basin the principal economic activity has mining and secondarily logging. While there are indigenous Pemón peoples working in the region and some working in mining, there are no indigenous communities within the area surveyed for this study, although there may have been some in the past. There is some evidence of this from "conucos" (familiar small farm) and a village toward the middle of the Uey River (Las Malocas section).

Level of Integrity

The areas studied present a gradient from medium to low integrity, based on the distance from human activities. The level of integrity is higher toward the upper basin of the Uey River in the Sierra del Lema, where there is very little human disturbance. In contrast, in the lower Cuyuní River Basin, there is much secondary vegetation where mining is active or has occurred within the last five to ten years, leaving large areas of forest with bare soil or partially covered with pioneer vegetation (non-woody). Within this area, cut tree trunks are evidence of logging that has been going on since 1885, primarily for balata (*Manilkara bidentata*). Mining activities in the region has occurred for less than 40 year.

Tertiary Criteria

Ability or capacity to generalize

This RAP survey compliments previous studies conducted in the lower and middle Cuyuní River, the Imataca Forest Reserve, and Sierra de Lema in the eastern section of Canaima National Park. The studies within the five focal areas established in this study provide a basic picture of the composition of the aquatic biota of the systems that extend above the confluence of the Cuyuní and Uey rivers. The results can be used as a baseline of the biodiversity of the middle and upper Cuyuní River Basin in Venezuela, and in general, of the Essequibo Basin in neighboring Guyana. The smaller headwaters as well as the vegetation and fauna of the Sierra de Lema present an important percentage of unique elements, and/or compared to other areas within the western Guayana Shield, they can only partially be extrapolated to the rest of the Shield.

Level of Knowledge

We now have a reasonable understanding of the alpha diversity of decapod crustaceans, terrestrial and aquatic vertebrates of the upper Cuyuní River Basin, as well as the vegetation structure and flora. However, more studies are needed in the sub-basin of the Uey River, especially inventories during other seasons, documentation of events of migration, seasonal movement between habitats, etc.

SUMMARY OF THE RAP RESULTS

Flora and Vegetation

This study presents a floristic structural characterization of the humid forests of a section of the middle-upper Cuyuní River Basin (confluence of the Uey and Cuyuní rivers) and of a part of the upper Uey River in the northern slopes of the Sierra de Lema. Both areas are included in the Imataca Forest Reserve. The forests studied were well developed, with canopy height up to 50 m and high forest cover, especially in the forests dominated by mora (*Mora* sp.). A large portion of the forest has been affected by small scale mining and by selective logging, especially the forests of the lower Cuyuní, along which large portions of the forest are secondary forest, some with over 40 years of secondary growth. Within the forests studied, tierre firme forest was more extensive than flooded forest, partly due to logging and the reduction in forest cover due to mining. The middle sub-basin of the Uey River is dominated by high and middle forest, and seems to have higher floral diversity than that of the Cuyuní River basin. The upper sub-basin of the Uey River, in the foothills of the Sierra de Lema, contains forests of medium stature whose species composition is similar to that of the Gran Sabana and the tepui environments at low altitude. In the tierra firme forest, the dominant families included the Caesalpiniaceae, Fabaceae, Apocynaceae, Caryocaraceae, Annonaceae, Moraceae, and Bombacaceae. The woody secondary communities were dominated by species of Clusiaceae, Flacourtiaceae, Cercropiaceae, Mimosaceae, Euphorbeaceae, Solanaceae, and Siparunaceae. The riparian forests and flooded forests, the most important families included Meliaceae, Burseraceae, Lecythidaceae, Mimosaceae, Chrysobalanaceae, and Myrtaceae, as well as some species of palms. More than 517 plant species have been seen or collected in the area of study.

Geochemistry of the Water

With the aim of characterizing the waters of the principal river channels and the streams pertaining to the upper Cuyuní River Basin, the RAP team described each sampling locality, measuring width, depth and coloration of the water, as well as determining various physical-chemical parameters including: pH, conductivity, dissolved oxygen, turbidity, and total dissolved solids. Additionally, samples of water (n=38) were taken at each sampling station to measure the prominent elements (Na, K, Ca and Mg), indicative elements (Fe, Al, Mn, and Cu), total suspended solids, dissolved organic carbon, and total and dissolved nutrients. In the upper and middle Cuyuní River, in the principal channel as well as the streams, the waters had pH values between 4.97 and 6.87, while the values of turbidity, total suspended and dissolved solids, and conductivity were relatively low, typical of rivers of black water originating in the Precambrian Guayana Shield. However, some

of the streams had elevated concentrations of suspended solids as a result of intensive mining activities in the area. There was a positive correlation between the elements Ca and Mg in the ecosystems studied. The concentrations of Na and K were significantly higher in Focal Area 3 (AF3). In Focal Areas AF5 and AF1 (Uey River Basin), more sampling stations had high dissolved organic carbon levels. The positive relationship between the dissolved elements Fe, Al and Cu with dissolved organic carbon suggest that the solubility of these elements was promoted by the concentration of humic substances in the solution. Waters coming from areas with high mining impact (station RAP-CY-AF2:16) had lower levels of dissolved organic carbon, which may be due to mining impacts on the upper soil layers.

Mercury

With the objective of evaluating the extent of mercury contamination in the upper Cuyuní River Basin, the RAP team measured the concentration of mercury in 36 samples of water, 25 samples of sediment, and 145 samples of tissue from fishes (n=131) and aquatic invertebrates (crabs, shrimps, and snails, n=14), from 56 different species, from the five focal areas studied. The Hazard Quotient (HQ), a risk assessment indicator that defines the ratio of exposure level to a single substance in relation to a reference dose, was calculated to determine the risk of ingestion of metal mercury (MeHg) through fish consumption. Mercury levels ranged from 6.55-421.53 ppb in the sediments, with factors of enrichment (FE) > 1 in 16 stations, indicating the addition of anthropogenic mercury. The minimum and maximum concentrations of Hg in water were 2.01 and 20.13 ppb respectively, in which the metal associated with suspended solids represented between 1.30 and 63.35%.

As a general rule, the concentration of mercury in the muscle tissue of fishes was greater than in the invertebrates. The fish species with levels of metal higher than the normal levels established by the OMS for human consumption (>500 ppb) were carnivorous fishes (piscivores and insectivores) with Hg values up to 27 times the values obtained from herbivorous fishes, suggesting a process of bio-accumulation of the metal. In addition, there was a strong association between the total length, weight, feeding habits and level of Hg in the fishes. The elevated level of Hg detected in fishes coming from the headwaters of the Uey River (a tributary of the Cuyuní River located in the Sierra de Lema), indicates that there is a transport of metal from the areas of small scale mining. The high values of HQ obtained suggest a serious risk for the health of the local human communities if they consume fish from this river system.

Aquatic Macroinvertebrates

The RAP team studied the richness and distribution of aquatic macroinvertebrates collected from the Uey River (lower, middle and upper basin), and from the Cuyuní River (before and after the confluence with the Uey River). The collections were taken over 13 days in January 2008, using nets, and manually, from a variety of habitats. The team collected 778 individuals representing 82 species of annelids, mollusks, and arthropods. The most diverse and abundant groups were (in decreasing order): Insecta, Crustacea, Mollusca and Annelida. The orders with the most species were Odonata (30 sp.), Coleoptera (9 sp.), Hemiptera (7 sp.), Decapoda (7 sp.), and Ephemeroptera (6 sp.). These orders also dominated in terms of abundance, with numbers of individuals ranging from 35 (Hemiptera) to 348 (Decapoda). In addition, the team collected species of Trichoptera (5 sp.), Diptera (4 sp.), Plecoptera (3 sp.), Megaloptera (1 sp.), Isopoda (4 sp.), Gastropoda (4 sp.), Bivalvia (1 sp.) and Annelida (1 sp.). This study recorded range extensions for the crabs, *Fredius estevisi* and *Microthelphusa bolivari*, the mollusks *Pomacea* sp. and *Pisidium* sp. and reported for the first time in Venezuela, the ephemeropteran *Leentvaaria palpalis*, the belastomatid *Weberiella rhomboids*, and the isopod *Parischioscia omissa*.

The five focal areas surveyed were similar in species richness and abundance, with a change in species composition along an ecological and altitudinal gradient. In general, there was a replacement of aquatic insect species with hydrological changes and substrate type along the river gradient; the change in species composition was also a product of the anthropogenic disturbance from mining, shown by the relation between increased concentration of suspended solids and the composition of species in the Cuyuní River after the confluence with the Uey River. The Uey River had less impact from mining - was sampled more than other areas - and contained a higher number of species and abundance of macro-invertebrates, thus warranting its consideration as a priority area for conservation of biodiversity.

Fishes

From January 18-31, 2008, the Cuyuní and Uey Rivers were surveyed to assess the fish fauna and to determine the principal threats in the region. The total species richness of fishes documented during the RAP survey was 125 species, from seven orders, of which the Characiformes had highest richness with 64 species (51.2%), followed by Siluriformes with 38 species (30.4%). The other orders each represented 8.8% or less of the fish fauna. The fish species belong to thirty-one families, of which Characidae was most species rich with 36 species (29%), much greater than the next richest family, Cichlidae) with ten species (8%). The other families were each represented by nine or fewer species.

The richest focal areas were the lower Uey River with 100 species, followed by the upper Cuyuní River (64 spp.), middle Uey (48 spp.), lower Cuyuní (34 spp.) and finally the upper Uey (5 spp.). A total of 133-150 fish species is estimated for the entire region. The characteristics associated with the ecosystems of the Uey and Cuyuní rivers such as the type of substrate, width, depth, current velocity, caudal, and temperature, determine the general establishment, structure and ecological function of the fish assemblies.

The most evident threats to the fish fauna are related to the mining activities throughout the basin, which have substantially modified the water quality of the Cuyuní River and the most important tributaries, such as the Junin. Likewise, mining has affected the surrounding forest ecosystems and is escalating at an alarming rate.

The RAP team recorded nine species not known previously from the Cuyuní River Basin in Venezuela, as well as six species that are new records for Venezuela. Six additional species are possibly new to science, increasing the total known fish fauna for the basin up to 229 species.

Amphibians and Reptiles

During the Upper Cuyuní RAP survey, the team recorded 53 species: 29 amphibians and 24 reptiles. The amphibians were all from the order Anura (frogs and toads), dominated by arboreal frogs of the family Hylidae (13 sp.), and terrestrial frogs of the family Leptodactylidae, with seven species. Reptiles were represented by one crocodile, the black babo *Paleosuchus trigonatus*, two species of turtles, 11 lizards from six families, and 10 snakes, most of which were from the family Colubridae. The colubrid *Chironius multiventris cochranae* is particularly noteworthy since it is a new record for the Bolívar State for the species, and the first record of the subspecies in Venezuela. The presence of the frogs, *Stefania scalae* and *Hyalinobatrachium taylori* in the middle Uey River Basin and 130 m elevation, increased their geographic and altitudinal distributions. The herpetofauna of the upper Cuyuní River Basin, especially the amphibians, is typically guayanese, with species endemic to the eastern Guayana Venezolana (Canaima National Park) present in the middle and upper Uey River, slopes of the Serranía de Lema. The presence of endemic species of the Sierra de Lema and the similarity between this mountain in terms of diversity and composition of the herpetofauna, provide evidence of a continuity of the biota in the lower elevations of the middle Uey River Basin. Based on these results, and the increasing threat from illegal mining in the area, it is recommended to protect the middle and upper Uey River basin.

Birds

During the RAP survey in January 2008, 254 species of birds were recorded, from 49 families, of which two species are migratory from North America. The record of *Cyanicterus cyanicterus* was particularly noteworthy due to the paucity of records for this species. Small range extensions were recorded for 11 species. The highest bird species richness was recorded in Focal Area 1, with 223 species, followed by Focal Area 2 and 3 (Cuyuní River) with 89 species, and lastly by Focal Area 4, with 16 species. In relation to geographic distribution, most of the bird species are wide ranging species, with only 126 species with ranges restricted to the Guayana region. The presence of birds typical of the subtropical forests of the Gran Sabana in the ombrophilous forests along the Uey River, help us understand the original distribution of these species and why isolated populations of these species exist in the Paria Peninsula, the Nuria altiplanicie, and other lowland areas of the Guayana region. The upper Cuyuní River Basin is included in the Imataca Forest Reserve, a region designated as an Important Bird Area (IBA) due to its high bird diversity and ecological value.

Mammals

During the RAP survey, mammals were inventoried in three focal areas along the Uey River, adding to our current knowledge of the mammal fauna of this region. In total, 87 species are now known from the region, from10 orders and 27 families. Forty-eight (48) species were documented during the 2008 RAP survey (19 collected, 12 direct observations or tracks, and 17 identified by local people) and 39 species were identified from museum collections. The species accumulation curve remained linear, indicating that the species richness is likely higher than recorded. The estimates with values above the rarefaction curve and its confidence interval confirm this. This indicates that further collections over longer periods of time, as well as the use of complementary sampling methods are needed to obtain a better estimate of the mammal fauna of the area. The bats were most diverse with 14 species (four families), with a clear dominance by two species that made up 56% of the individuals captured (*Rhinophylla pumilio* and *Pteronotus parnellii*). The success in capturing small non-volant mammals was very low, with only three species recorded (*Didelphis marsupialis*, *Proechimys guyanensis* and *Makalata didelpoides*). The low capture rate was possibly a reflection of low densities of each species, and probably was associated with the long, heavy rains that occurred during the survey.

Of the 87 species recorded, 15 (17%) are restricted to the Guayana region, nine species (10%) are known from two or three bioregions in Venezuela, while the remaining 63 (72%) are widely distributed throughout the country. In relation to habitat use, all the species are known to be associated with timber forests, with most found in evergreen forest. The mammal fauna of the area can be characterized into eight trophic levels, with frugivores, insectivores, and omnivores the most dominant. With respect to the value of the species for human use, 19 species are of cinegetic interest, and since most have a commercial or food use, most are under threat. Based on these results and the level of human impact in the area, it is essential to put forth strategies for the protection and management of the regional mammal fauna, including more baseline studies, training of personnel in conservation of natural resources, and implementation of models of development that promote biodiversity conservation in spite of the threats facing the region.

Threats

The most evident threat is the impact generated by gold mining, and its associated activities, on biodiversity in a very broad sense. The impacts are wide due to the level of impacts (magnitude) as well as the fact that they affect both terrestrial and aquatic ecosystems. Some specific threats include:

- The mining practiced in this region focuses on exploitation of deposits and soil profiles containing gold. To do this the miners remove gold from shoreline deposits and from the bottom of stream channels and branches, and banks of larger rivers, and "regolitos" that are easy to excavate. The residue from these activities are deposited directly into the rivers, which notably affects the geochemical characteristics of the water, substantially increases the amount of particles suspended or found at the bottom, fills in the river beds, and increases the turbidity of the waters. This, at the same time, destroys the benthic ecosystems and

substantially limits the visibility, affecting fishes, birds and mammals that depend on these water sources. The most striking example of these impacts observed during the RAP survey was found in the Quebrada Amarilla.

- Although in general, the team observed a replacement of aquatic insect species with hydrologic changes and the substrate type along the hydrographic gradient, the change in species composition and the loss of diversity observed was also due to perturbation of the system by mining, as evidenced by the correlation between the level of suspended total solids and species composition in the Cuyuní River after the confluence with the Uey River. Aquatic insects, due to their physiology, are especially susceptible to this type of perturbation.

- The greatest threat to the fish fauna is related to small-scale mining throughout the basin, which has substantially modified the quality of water in the Cuyuní River and its most important tributaries, like the Junin. Mining has also affected the surrounding forest ecosystems and continues to increase at an alarming rate.

- The concentration of mercury in tissues from fish muscles was found to be greater than from invertebrates. The fish species that showed levels of mercury higher than the norm established by OMS for human consumption (>500 ppm) were all carnivorous fishes (fish and insect eaters) with values of Hg up to 27 times higher than obtained from herbivorous fishes, suggesting that the metal is bio-accumulating in the fishes. The high levels of mercury in fishes from the headwaters of the Uey River indicate that the metal is being transported from the mining areas into these pristine areas. This is a serious threat to biodiversity because the impacts of mining are not only felt close to the mining activities, but also over a much wider area within the aquatic system.

- The Hazard Quotient (HQ) was calculated to determine the risk to humans from eating affected fishes. The range of mercury values obtained from the sediments was 6.55-421.53 ppb, with enrichment factors (FE) > 1 in 16 sampling stations, indicating the addition of mercury into the system by humans. The minimum and maximum concentrations of Hg in water were 2.01 and 20.13 ppb respectively, and in suspended solids levels ranged from 1.30 to 63.35%. The high HQ values suggest that the local human community is at high risk of mercury poisoning from eating fish from this system.

- Lastly, but not least importantly, there are serious threats associated with activities using mercury, such as the discarding of gasoline and oil into the soils and water, and depositing of waste water and solids directly into the forest and water. The water takes these discarded substances downstream, thus increasing the impacts of the mining activities.

- The current levels of logging and deforestation are also a serious threat, although not as imminent as mining. These activities result in a loss and fragmentation of habitats, with their impacts already observable in the vegetation and terrestrial vertebrate fauna.

CONSERVATION RECOMMENDATIONS

Based on the RAP results and general observations throughout the basin, the following recommendations are proposed for the conservation of biodiversity and ecosystems of the upper Cuyuní River Basin:

- Establish a protected area in the middle and upper part of the Uey River Basin, through a collaborative strategy involving governmental and non-governmental institutions, local miners, and Gold Reserve de Venezuela C. A. – Compañía Aurífera Brisas del Cuyuní C. A.

- Quantify the extent of the forests and lands that have been modified and determine plan for restoration, as well as undertake comparative studies of the biodiversity of the pristine areas with the areas altered by humans.

- Continue to analyze the mercury contamination in the water, sediments, invertebrates, fishes and humans on a temporal (hydrological cycle) and spatial scales (entire basin).

- We recommend the immediate application of means to prevent the increase in artisanal mining in the area. This must be accompanied by a program to reduce the emissions of mercury through education and training the miners in the process of gold extraction (by "retortas" that is a device to "burn" the mercury), which are widely distributed among those who work with the burning of amalgams. This can have a significant effect on reducing the level of mercury in the Cuyuní River Basin, since recovery of this metal is over 98% when the "retorta" is used. In addition, not only efficiency but also the quality of the gold has been found to be enhanced by miners in other areas who use the "retorta".

- Raise awareness among the local communities, principally the miners, of the risks of ingesting fishes, especially the carnivores that are in most frequently caught and eaten (e.g. aimara, payaras, curvinatas, etc.) and substitute these with smaller species that are herbivores, omnivores or detritivores. It is especially important that pregnant women do not eat these carnivorous fishes, since the high mercury levels in these fishes can seriously affect the development of the fetus.

- Evaluate in a detailed manner the impact of mining activities on the fish communities and aquatic insects in the streams, by sampling over a wider geographic area and sample streams that are currently and have in

the past been impacted by mining, as well as streams in pristine condition.

- Support and provide incentives for the development of programs aimed at sustainable use of the resources of the zone, which enhances the quality of life of the local human communities as well as biodiversity.

- Develop a protocol for a long term biodiversity monitoring program in the Upper Cuyuní River Basin, including key plant and animal species (endemics, threatened species, human use, etc.) that can be part of sustainable development projects.

- Establish a biological station on the Uey River and develop courses for training of parabiologists or local environmental monitors, including the miners.

- Complement the results of the RAP survey with additional surveys in the dry season to obtain a more complete picture of the diversity of aquatic invertebrates, fishes, reptiles, mammals and birds; and in the rainy season for amphibians, birds and mammals.

- Given that the sub-basin of the Uey River remains in a state least altered by humans within the Cuyuní River Basin, and also has high biodiversity importance- high diversity and endemism- we recommend that a biological and monitoring station be established there which will promote the area as a protected zone and buffer between Canaima National Park and mining activities.