Rapid Hydrological Analysis of the Los Negros Watershed in support of a Payments-for-Environmental Services (PES) Mechanism

INTERIM REPORT FROM FUNDACION NATURA BOLIVIA TO CIFOR DESCRIBING PROJECT ADVANCES JANUARY-DECEMBER 2005

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Project Justification

Hydrological research is expensive and time consuming. If Payments for Environmental Services (PES) systems are really to integrate forest conservation and sustainable development in the world's poorest and most biodiverse watersheds, the forestry research community needs to find a quick and easy way of undertaking a sufficient level of hydrological analysis that while providing data of sufficient accuracy to guide the development of PES systems, can be collected cheaply and rapidly by local institutions.

Though many of the nascent payments for watershed services systems in Latin America have been studied and analyzed by researchers, little attention has been paid to what is perhaps the most important basis of all such systems: the hydrological characteristics of the watersheds that are purportedly providing the "environmental service". In most systems, there is simply an assumption that reducing forest degradation will maintain stream flow. In other words, most existing PES systems have at their fundamental base an untested assumption of a direct forest/water relationship.

With support from the Centre for International Forestry Research, Natura Bolivia is undertaking a *Rapid Hydrological Analysis of the Los Negros Watershed*. Not only will this study provide hydrological data for Natura's incipient Los Negros Valley PES system, but it will also provide guidance to the forestry research community, CIFOR, and practitioners on whether it is possible to undertake rapid, inexpensive hydrological analyses that can provide a reasonably robust scientific basis for PES systems.

In the Rio Los Negros watershed, in Bolivia's mesothermic valleys, there is a registered concern over the state of the river, especially the water level. Preliminary results of a survey conducted in the watershed point to an overwhelming consensus that the river is much lower than it was in past decades and that the level continues to diminish, especially in the dry season. According to local residents, the main water problems are erosion, diminished water flow and sedimentation.

In order to quickly address what is a temporal phenomena (i.e. over time, with continued deforestation, stream flow will reduce), we reformulated the question as a spatial hypothesis: *micro watersheds that are already deforested will produce less dry season water than micro watersheds that still maintain their forest cover*. Our interest is differences in water flow in the dry season, when lack of water becomes the limiting factor for agricultural productivity. By assessing relative wet season/dry season flows within each micro watershed, we will factor out differences in the size of the watersheds. The hypothesis we are testing, therefore, is that:

In comparison with wet season stream flow, dry season stream flow in deforested watersheds will be relatively lower than dry season stream flow in watersheds that still retain forest cover.

We expect that such results, if sufficiently differentiated, will be appropriate for assessing the validity of assuming the forest/water relationship. In addition to stream flow measurements we ware also measuring precipitation in the micro watersheds. This will allow us to assess if differences in rainfall regimes could cause hydrological patterns.

Methodology and progress in 2005

Stream flow measurements

In the original proposal we described how we planned to construct weirs to measure streamflow in eight micro-watersheds, four with extensive forest cover, and four that have essentially been deforested. However, we were quickly forced to adapt his proposal as we adjusted our plans to the reality in the field. The main technical difficulty of building weirs, as explained to us by two consultant hydrologists, is that the streams in the upper Los Negros watershed are highly dynamic, and so the type of weir that would be appropriate for measurements in the dry season would be destroyed and washed away in the wet season. We therefore decided to instead build cement "channels" (see photos 1 and 2) that allow standardized measurements by canalizing the stream, but do not totally block water flow, as a weir would.

The second problem we faced was the unwillingness of several landowners to allow any constructions on their streams. This precluded us from building measuring channels at all the sites we wanted. Given this reality, we were forced to think again, and so in addition to the five sites where we could construct channels, we located measuring stations on five streams where we could undertake suitable measurements without the benefit of a canalized stream (photo 3).

Though this development was not what we would have preferred, we decided to take advantage of the situation and we will explicitly compare the results of our research in the "canalized" and the non-"canalized" streams. We will thus incorporate into the overall study an analysis of whether for such a rapid hydrological assessment it is actually necessary to undertake any of the construction activities we originally proposed. If researchers can collect good enough data simply by measuring stream depth with neither weirs nor channels—as we have been forced to do for political reasons—in five of our streams, the rapid hydrological assessment tool could be even less expensive and quicker than we had first imagined.

In addition to the ten small streams (five "canalized" and five non-"canalized") in which we are comparing the effect on dry season water flow of differences in land use, we are also collecting hydrological data on two secondary branches of the Los Negros river into which the streams flow (photo 4), and at five points on the main river itself, including in the town of Los Negros, giving a total of 17 measuring stations.

Data collected at each site includes:

- Water depth (in cm) at 50 cm intervals across the channel (3 times per week)
- Stream velocity (in metres/second) at 50 cm intervals across the channel, measured at a depth of ~ 0.66% of the stream depth at that point (see photo 5) (once per week in the dry season, and once a month in the logistically much more difficult wet season).

Preliminary water depth measurements were taken in May 2005, with full-scale data collection starting in June. Measurements are made using a graduated ruler, and a line, marked at 50 cm intervals, that is strung across the channel during measurements. Stream velocity has been measured since July 2005 (with a FP 101 flow probe purchased from Global water Instrumentation, Inc. (http://www.globalw.com) for $695).

Given stream depth (cm) and average stream velocity (meters per second), simple mathematics allows a calculation of total stream discharge in litres per second. Hydrological research has shown that for a given measuring location, once the stream has been calibrated (i.e. its average velocity has been calculated and graphed for a range of depths), future monitoring requires only the measuring of stream depth. After calibration, from the simple depth data, the average velocity can then be interpolated and discharge calculated.

To better exemplify the data collected at each measuring station, below follows an explanation of the data collected at station #1 on October 13th 2005 (see enclosed sample data sheet). This station is located on the property of Angel Ayala, at the geographic coordinates of 366053, 8028264 at an altitude of 1723 metres above sea level. On October 13th 2005 stream # 1 had a channel width of 4 metres (on this particular stream we constructed a measuring channel (photos 1 and 2) so this measuring point always has the same width, while some of the other stream widths vary with water flow (e.g. photo 3). At 0.5 metres distance from the right hand edge of the channel, the stream had a depth of 3 cm, and an average velocity of 0.56 metres/second while at 0.5 metres distance from the left hand edge of the channel the stream depth was 4 cm with an average velocity of 0.7 metres/second.

Rainfall measurements

We have located 8 pluviometers (rain gauges) in various parts of the upper watershed. These rain gauges automatically record rainfall (in 1 mm increments) for one year, and their memories can be downloaded onto a PC and the results tabulated and graphed (rainlog data loggers and polypropylene rain collectors purchased from Rainwise, Inc. (http://www.rainwise.com) for $200 each). We located three gauges in the headwaters of our small streams, high in the upper watershed's cloud forests, three gauges in lower reaches of our small streams in the moist forest/agricultural fields above Santa Rosa, and two gauges in the village of Santa Rosa. Data will complement government-collected rainfall data in the downstream town of Los Negros, though we also plan to locate another rain gauge in Los Negros.

Participatory data collection and project institutionalization

As mentioned above, the project has run into political difficulties in that some farmers have refused to allow construction of channels on their land. There have also been various discussions in the community about what we are trying to achieve with the project, and fears have been raised that we are simply measuring the stream flow in order to charge the farmers for water. In addition, one of our rain gauges (a $200 value), although located "safely" on one of our farmer-collaborator's fields, was stolen and taken apart by a curious day-labourer.

We have tried to reduce such risks in a number of ways. From the start we have presented this entire project not as an initiative of Natura, but as the undergraduate thesis of a student, Alex Carrasco. This was certainly a good strategy as a number of potential troublemakers were placated by the idea that this was simply a thesis project. However, the downside of this strategy is that we have had to run the project at the student's pace, rather than ours, so we are rather behind schedule. Indeed, we were getting so delayed that we have now taken day-to-day data collection out of the student's hands, in order to proceed more rapidly.

Our second risk reduction strategy was to hire two farmers, Asterio Ayala and Demetrio Vargas to be primary data collectors. Although we have had some problems in ensuring equivalency of data collection, this strategy has proved successful as the data is almost always collected on time, cheaply, and by people who are totally acceptable to the community. We have also requested and received a Municipal ordinance # 011/2005 that recognizes the project and requests of everyone in the municipality, the protection of the measuring stations, rain gauges and data collection activities

Expenditures 2005

	Approved Budget (CIFOR)	**Actual expenditure to Nov. 30th 2005**
Salaries for technical support	1500	750
Field technicians' salaries and expenses	600	300
Material for dam/channel construction	1800	1952.01
Rain gauges	1600	1999.06
Model calibration	500	27.37
TOTAL	**6000**	**5027.44**

Planned activities 2006

Because of various political difficulties, project activities started far later than we had expected, so we are behind schedule, having only really initiated full-scale data collection in July 2005. Data will be collected on the described schedule (stream depth three times per week, stream flow once a month in the wet season and once a week in the dry season, and rainfall continuously) until July 2006. We will then analyze the data and prepare the final report by August 2006.