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Forest hydrology project (UFSC–MOBASA) for water resources management in Rio Negrinho City, Santa Catarina, Brazil

MASATO KOBIYAMA[1], TATIANE CHECCHIA[1], CLAUDIA W. CORSEUIL[1], JOÃO F. L. LINO[1], NADIA H. Y. LOPES[1], FERNANDO GRISON[1], PEDRO L. B. CHAFFE[1], SIMONE MALUTTA[1], ULISSES RIBAS JUNIOR[2], REINALDO LANGA[2] & SANDRO BASSO[2]

1 *Department of Sanitary and Environmental Engineering, Federal University of Santa Catarina, Caixa Postal 476, Florianopolis, SC 88040-900, Brazil*
kobiyama@ens.ufsc.br

2 *Modo Battistella Reflorestamento S.A.–MOBASA, BR-280 Km133 Acesso Rio Preto Velho, Rio Negrinho, SC 89295-000, Brazil*

Abstract The remainder of the Subtropical Ombrophilous Forest (SOF), which covered the plateau region of southern Brazil, is now only 2% of its original area. Today environmentalists and local communities request the conversion of the pine reforestation areas to the SOF, discounting that the regional economy depends mainly on the reforestation activities. To answer the question of which is better for the water resources management, native forest or pine reforestation, the Federal University of Santa Catarina (UFSC) and the Modo Battistella Reflorestamento SA (MOBASA) started the Forest Hydrology Project (UFSC–MOBASA) in Rio Negrinho City, Santa Catarina State. The project consists of: (1) scientific activities (monitoring and modelling); and (2) extension activities (environmental education courses), having seven experimental school catchments. Since there are few research projects on SOF hydrology, the present project serves as a pilot undertaking for this region.

Key words environmental education; experimental school catchment; forest hydrology; pine reforestation; Subtropical Ombrophilous Forest

INTRODUCTION

The forest in the plateau region of southern Brazil was represented mainly by the Subtropical Ombrophilous Forest (SOF). This forest was characterized by araucaria (*Araucaria angustifolia*), imbuia (*Ocotea porosa*), canela sassafras (*Ocotea odorifera*) and xaxim (*Dicksonia sellowiana*) which are all on the extinct species list. Such vegetation originally covered 43% of Santa Catarina State (Medeiros *et al.*, 2004). During more than a century of economic exploration without planning, this rich and unique forest has been converted to agriculture, cattle breeding and reforestation land, (especially pine trees), reaching a visible biological decay situation. Now the rare native forest occupies only 2% of its original area.

By citing water quality deterioration and its quantity reduction, environmentalists and local communities condemn the pine reforestation activities. They request the

conversion of the pine areas to SOF, without taking into account that the regional economy depends mainly on the reforestation activities.

Which is best for sustainable water resources management in this region, native forest, pine reforestation or agriculture? To answer this question, it is essential to carry out hydrological monitoring and modelling with representative experimental catchments.

Of late, global climate change has been intensely and widely discussed. For this topic it is very important to evaluate the determinant factors on the climate. One of them is the forest function in the hydrological cycle (Gerten *et al.*, 2004). Therefore, forest hydrology possesses both local and global aspects.

RIO NEGRINHO CITY

Rio Negrinho City (908.9 km^2), which is located in the north of Santa Catarina State (95 318.3 km^2), has a population of about 40 000, and its economy relies mainly on the forest products industry (Fig. 1). As its mean altitude is 792 m, the climate is Cfb (Maritime Temperate climate) in the Köppen classification. The principal geology is Paleozoic sedimentary rocks (sandstone and shale) that demonstrate horizontal stratification. The general relief is moderate and there are a lot of swamps in headwater areas.

This city is in an anxious situation with regard to the crisis of the Negrinho River that supplies drinking-water. An accelerated and unplanned urbanization has resulted in the reduction of the water quality and quantity. The human intervention (agriculture and forestry) in the rural area causes the reduction of the water infiltration rate and the consequent increase of the surface flow, which generates soil erosion. And the urban area has frequently suffered from the hydrological extreme events (flood and drought).

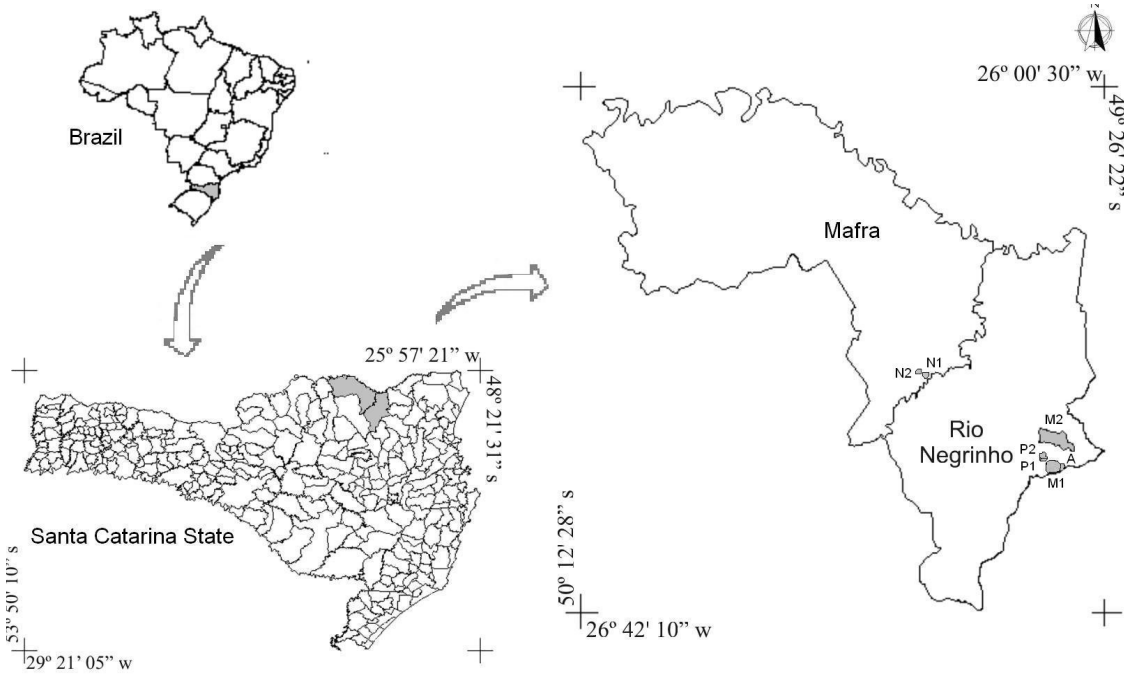

Fig. 1 Locality of Rio Negrinho City.

Analysing the history of the city, Schoeffel (2004) identified the increase of hazard zones occupation in the urban area, and emphasized the fundamental roles of the city office's actions to reduce flood disasters.

PREVIOUS STUDY

By estimating the potential evapotranspiration (ETP) with the Thornthwaite method, Kobiyama *et al.* (2004a) studied some regional climate characteristics of this city. The mean annual temperature was 18.3°C. The annual ETP and runoff were 54.6% and 45.4% of the precipitation (1572 mm/year), respectively.

For the preliminary study to verify the hydrological influences of the native forest and the pine reforestation, three small experimental catchments in Rio Negrinho City were established, one characterized by SOF (52.5 ha) and the other two (29.7 ha and 32.5 ha) by *Pinus taeda* L. reforestation. In these catchments, runoff and rainfall were measured daily with a Parshall flume and a rainfall gauge, respectively. Water samples were collected monthly for the water quality analysis. The highest mean runoff was found in the native forest catchment. Significant differences in water quality among the catchments were not verified statistically (Kobiyama *et al.*, 2004b).

Although the catchment size was very small in this preliminary study, the measurement time interval was not short enough, which caused difficulties in discussing the hydrological influences of the land uses in small catchments. Furthermore, the hydrological effect of agriculture was not evaluated.

FOREST HYDROLOGY PROJECT (UFSC–MOBASA)

To solve the aforementioned problems, the Federal University of Santa Catarina (UFSC) and the Modo Battistella Reflorestamento SA (MOBASA) started the Forest Hydrology Project in Rio Negrinho City. This project is a part of the MOBASA Environmental Project, which treats fauna, flora, soil and water.

Scientific activities (hydrological monitoring)

This project has seven experimental catchments: two catchments characterized by the *Pinus taeda* reforestation (P1 = 23.8 ha and P2 = 17.5 ha); two by the secondary native forest (N1 =15.9 ha and N2 = 24.1 ha); one by agriculture (A = 19.7 ha); and two mixtures characterized by the mosaic structure of three different land uses (M1 = 268.6 ha and M2 = 887 ha) (Figs 1 and 2). The predominant soils in the seven catchments are Inceptisol and Entisol, whose texture is loamy. Since it was difficult to find suitable experimental catchments characterized by the native forest, N1 and N2 were constructed in Mafra City, but very near the border of Rio Negrinho City.

In all the catchments, the runoff and the turbidity are automatically monitored at 10 min intervals. In the M1, M2 and N1 catchments, the precipitation and solar radiation are also monitored automatically with the same interval.

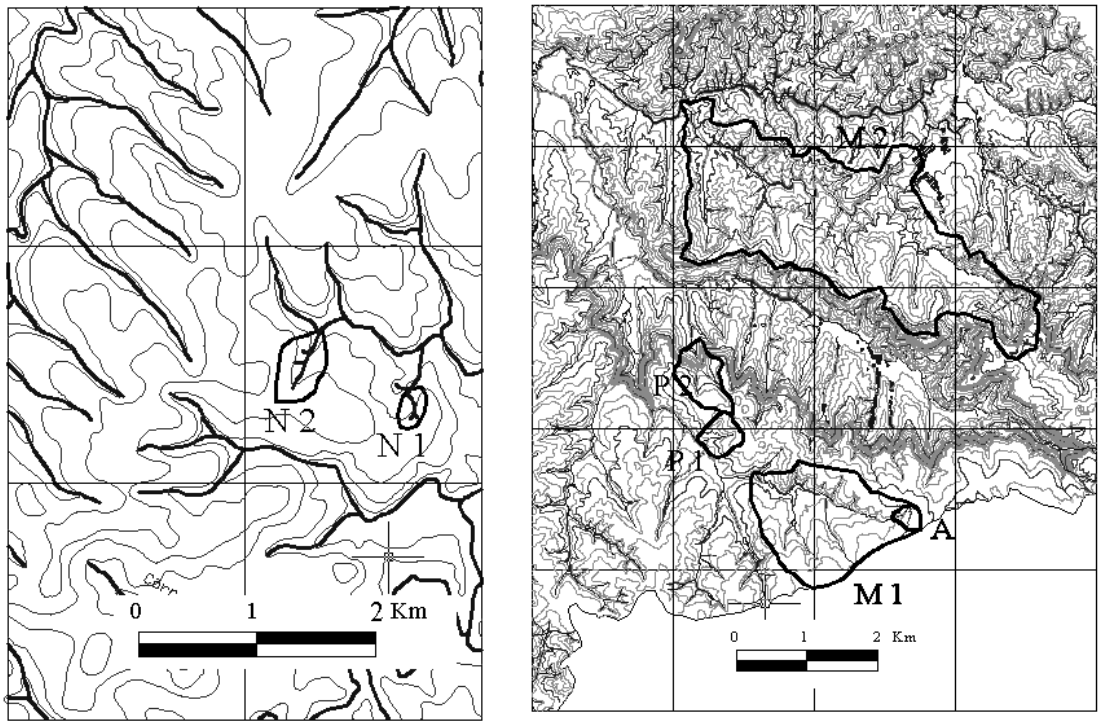

Fig. 2 Experimental catchments' locations.

Extension activities (environmental education)

According to Mendiondo (2002), the school catchment is a support infrastructure where the scientific research and the technological development in water resources management permit social participation. Since the school catchment interconnects science, technology and innovation, its establishment is fundamental in sustainable development. That is why the present project calls all the experimental catchments school catchments. All the experimental school catchments are used for the environmental education activities in local communities and also for the qualification lectures for technicians that work for the water and forest resources. In this sense, school catchment can be defined as an experimental catchment which serves scientific research and environmental education activities.

PRELIMINARY RESULTS AND DISCUSSION

Hydrological monitoring

Figure 3 shows the rainfall and runoff observed on 6 December 2006, in the N1 and N2 catchments. The measurement interval is 10 mins.

A comparison of the hydrograph between N1 and P1 catchments is shown in Fig. 4. The variation in the hydrograph of P1 is larger than that of N1. This difference may simply have resulted from the forest type. But in this case, the soil condition effect may be more considerable. Through the soil survey, it was found that the P1 catchment has no or a very thin A horizon layer. Formerly, the land levelling before

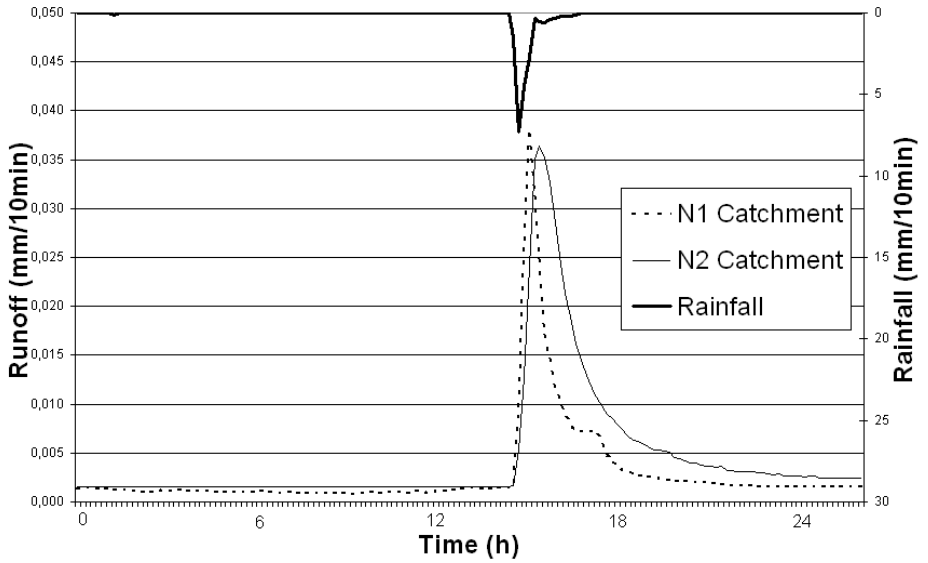

Fig. 3 Rainfall and runoff on 6 December 2006, in N1 and N2 catchments.

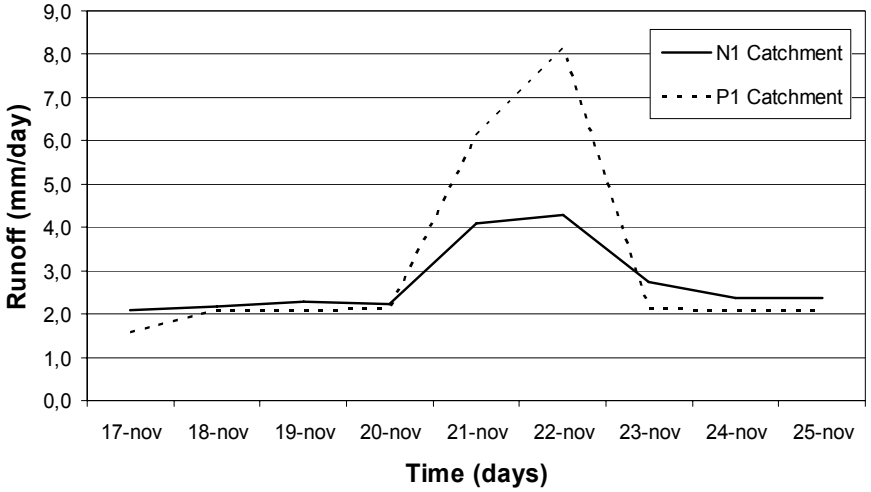

Fig. 4 Runoff during the period 17-25 November 2006, in N1 and P1 catchments.

planting seedlings had been always achieved in the region of Rio Negrinho City. This forest practice stripped off the greater part of the A horizon layer, which has a high retention capacity and permeability to the soil water. In the P1 catchment, the soil with very poor A horizon increases the runoff peak and reduces the runoff quickly after the rainfall event. It is noted that the land levelling that removes the A horizon layer has not been recently practiced because of the knowledge that this layer contains a lot of nutrients for plants.

Extension activities

Until now three courses were executed (Table 1). The course “Learning hydrology for natural disaster prevention” was run twice and the others were only once. Normally

Table 1 Courses run as extension activities in Rio Negrinho.

Title	Participants	Duration	Collaborator
Water resources and forest	General public	2 h	Environment Group of ACIRNE*
Introduction to natural disaster prevention	City office, fire station and civil defence corps officers	12 h	Environment Group of ACIRNE
Learning hydrology for natural disaster prevention	Primary school teachers	4 h	City office

* ACIRNE: Association of Commerce and Industry of Rio Negrinho.

each course prepares one textbook or pamphlet. In the case of the course "Introduction to natural disaster prevention", one book (Kobiyama *et al.*, 2006) was used.

In each course, the relationship between the water resources and the forest was treated and discussed. All the participants confirmed that pertinent management of water and forest can reduce natural disasters (floods, landslide, drought, etc.). According to the replies submitted to questionnaires about the courses, most of the participants really want to attend more complementary courses that relate forest, water resources and natural disasters.

Rio Negrinho City, located in the countryside, does not have researchers or information enough to recognize the relationship between water and forest. The local communities require universities to provide some scientific and technical support, which implies that the participation of UFSC in the Forest Hydrology Project is very important. As the reforestation companies like MOBASA possess a lot of headwater catchments, the participation of such companies in any forest hydrology project is fundamental. It might be almost impossible to construct any experimental catchments without the cooperation of reforestation companies. It can be said that the cooperation between UFSC and MOBASA converted the common headwater catchments to the experimental catchments. Furthermore, a realization of some courses (environmental education) with the participation of local communities converts them to the school catchments (Fig. 5).

It is very clear that visiting experimental catchments allows a person to understand hydrology better. Probably only construction and utilization of school catchments will contribute to answer the community's questions about water resources management. This kind of cooperation between universities and reforestation companies, together with local communities' participation, might be indispensable in any forest hydrology project which ensures the integrated management of water resources.

In this way, school catchments increase an individual's knowledge of hydrology, which enhances individual participation in the community. Consequently, an enhanced participation of each member elevates the quantity and quality of the community action. According to Hillman & Brierley (2005), the community-based management is essential for the recent stream rehabilitation programmes. This type of management with governmental supports must be executed for any programme that treats catchments and water resources. Figure 6 shows the relationship between the school catchments and the community-based management.

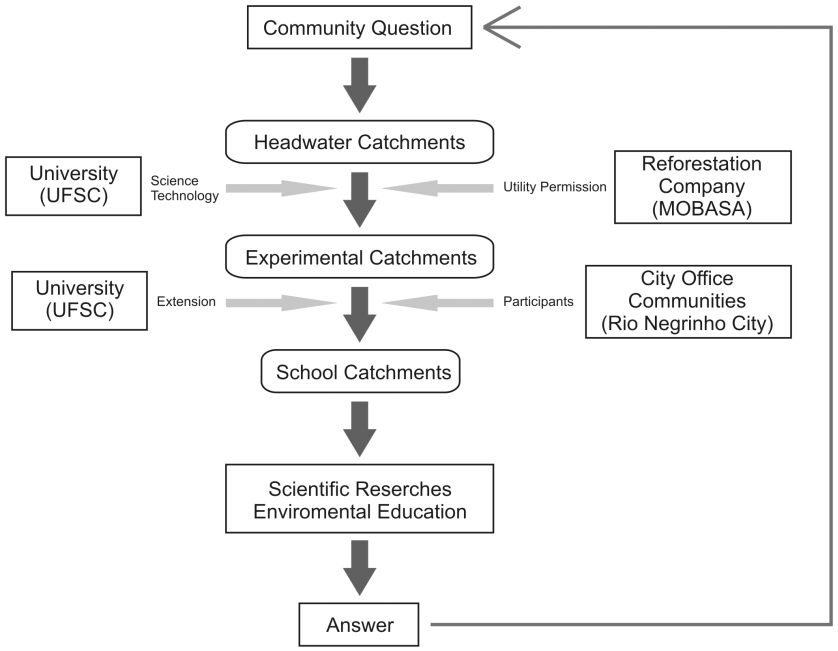

Fig. 5 Flowchart of Forest Hydrology Project (UFSC–MOBASA).

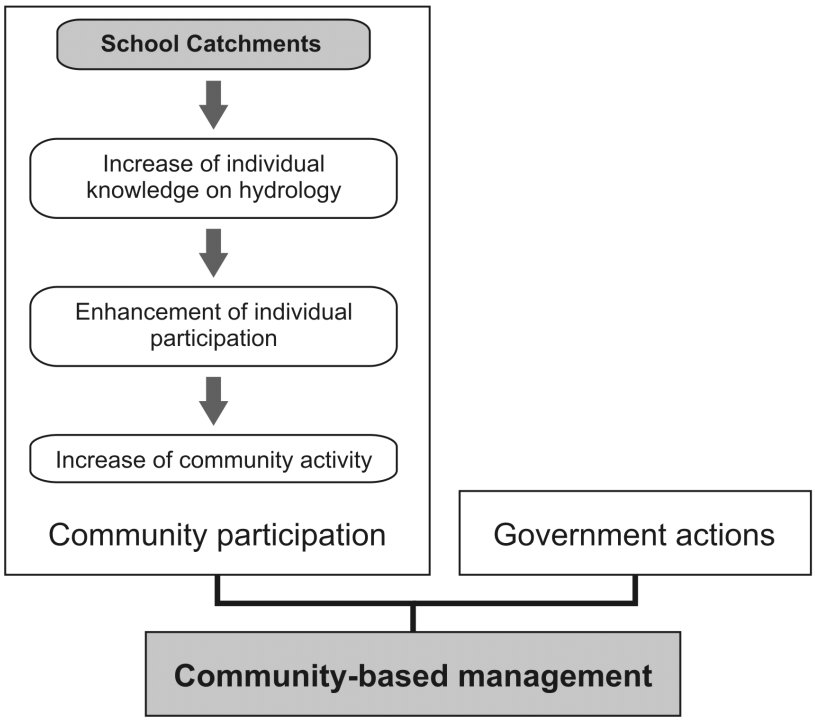

Fig. 6 Relation between school catchments and community-based management.

FINAL CONSIDERATIONS

The Forest Hydrology Project (UFSC–MOBASA) has started only recently with the purpose of contributing to the water resources management in Rio Negrinho City. This

project has two main activities: (1) hydrological monitoring and modelling; and (2) extension activities (environmental education). A final goal of this project is to answer which is better for water resources management, natural forest or pine reforestation.

Seven experimental school catchments have already been constructed with automatic monitoring systems. In the near future, some mathematical models will be applied to understand more hydrological processes on different land uses and to have various hydrological scenarios which respond to the land-use changes.

Any results obtained in these school catchments will possess persuasive powers to local communities, more than those in other catchments (especially foreign catchments). That is why the communities will place reliance on technical suggestions resulting from the school catchments. For example, from the hydrological point of view, Fig. 4 affirmed to the local communities the fact that the A horizon layer must be maintained.

Since there is little research on the hydrological processes of the SOF and pine trees in Brazil, the present school catchments will serve as a pilot undertaking and contribute to constructing the community-based management of water resources for this region.

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