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Developing strategies for managing Andean agroecosystems in Colombia

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Introduction

The Otun basin river is located in the central range mountain of the Colombian Andeans. This area includes an interesting complex of relationships and dynamics between natural ecosystems and human population (Rodriguez 2009; Uribe 2009). Highlands between 2000 and 4000 masl are important for providing ecosystems services and lowlands between 2000 and 900 masl represent the territory for urban settlements and rural activities. Approximately 500.000 people settled in the coffee region of Colombia (city of Pereira) depend on goods and services provided by natural ecosystems and agroecosystems. Most of the highlands surface (above 4000 absl) belong to protected areas conformed by paramo ecosystems which fulfil significant ecological functions of regulating water resources. Buffering areas of paramo ecosystems (2000-4000 absl) are covered by Andean tropical cloud forest whit high although breakable biodiversity. Lowlands (2000- 900 absl) conform a mixed landscape with agriculture, livestock and remnants of forest. Remnants of forest accomplish important ecological functions such biodiversity refuge and stepping stones for ecological restoration processes as well.

Currently conditions of this significant area in Colombia are threatened by degradation of natural resources and lately by climate variability. As a consequence ecological processes are being shaken and some changes have been elucidated (Arias et al . 2009; Dossman et al. 2010).

Territorial security is now a priority which permits to face integrally ecosystems degradation. Currently, polities, institutional strengthening as well as strategies of adaptation through planning and incorporation of adequate practices within farm systems, are being implemented for contributing to territorial security and additionally to increase agroecosystems resilience. Information generated when monitoring biodiversity (functional groups), soil and water, has permitted to define agroecosytems vulnerability and elucidate measures of adaptation. In this sense, actions addressed from different sectors and stakeholders, taking in account particularities of each farm systems, are providing the bases to develop strategies for managing properly agroecosystems.

Taking into account the above mentioned, the estimation of carbon content fixed in soils under different uses and cover of land as well an approach to the definition of ecosystems services have permitted to elucidate which farm systems or which land cover contribute better with a

sustainable development of rural areas in Colombia and provide the bases for developing strategies for managing Andean agroecosystems.

Material and Methods

Carbon content in soils was estimated for different areas in the Otun river basin (Andean of Colombia). This study area was divided in four ecosystems according elevation as follow: transformed ecosystems (sector La Florida); sub-Andean forest ecosystems (La Suiza–El Cedral); high –Andean forest ecosystems (El Cedral–Peña Bonita) and paramo ecosystem (Laguna del Otún).

Additionally, an approach to define ecosystems services provide by soils was developed. The first step consist of the evaluation of soils characteristics under different cover. Then integrating soils characteristics it was possible to define qualities and by defining threshold of each quality were define ranges to qualify six ecosystems services: nutrient availability, erosion resistance, rooting capability, water availability and capability of CO_2 fixation. Values of ecosystems services were then compared among covers by means of non parametric methods

Results and Discussion

After sampling and determination of carbon, an average of 234 t C ha^{-1}, at 50 cm of depth was found. Non parametric tests showed that C content in soils significantly ($P<0,05$) varied between the ecosystems compared. Low values were found under transformed ecosystems (198 t C ha^{-1}) while the higher values were found in high –Andean forest ecosystems and paramo (Figure 1). Higher values match with ecosystems where protected areas are predominant and not necessarily are associated with differences in soils properties.

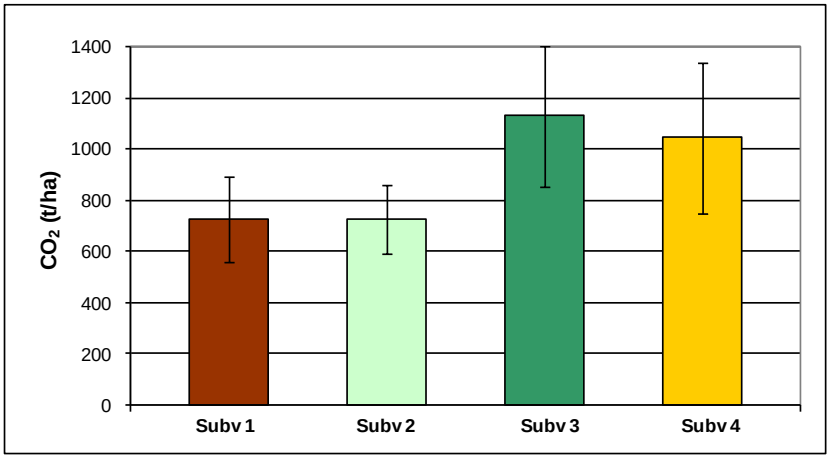

Figure 1. Average of soil carbon content (t/ha). Subv 1 = transformed ecosystems; Subv 2 = sub-Andean forest ecosystems; Subv 3 = high –Andean forest ecosystems; Subv 4 = paramo ecosystem. Verticals lines on bars represent standard deviation.

The amount of carbon found in paramo soils is associated to its stability, because of temperature and alophane content. This condition should be highlighted as an additional factor to promote the conservation of these ecosystems. In fact, some authors have also suggested the needed of a proper management for paramo ecosystems (Rondon et al., 2002). Comparisons between covers within the ecosystems evaluated also show a tendency of higher values for forest and natural covers (paramo vegetation) (Figure 2). Significant amounts of carbon stored in soil even under agricultural uses, evidence the importance of soil providing support for food production but also ecosystems services. Therefore, it is also important to remark that those farm systems with higher diversity represented in their structure (ie. Inclusion of trees) represent better environmental conditions and also higher carbon content.

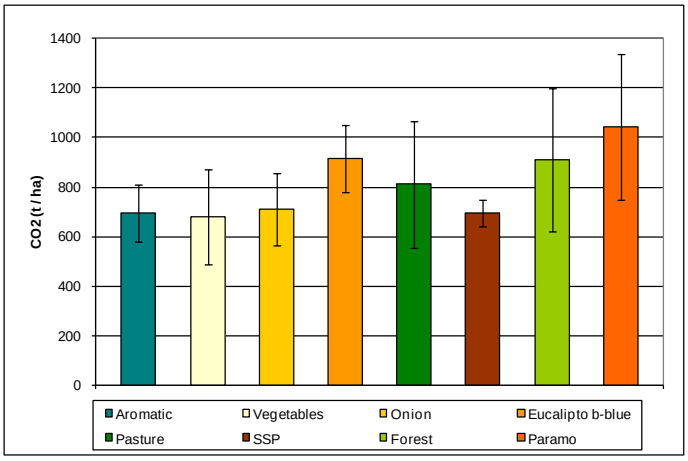

Figure 2. Average of soil carbon content (t/ha) under different land cover. SSP= silvopastoral systems; b-blue = ornamental variety. Verticals lines on bars represent standard deviation.

Differences on the six ecosystems services evaluated showed relationships with aspects associated with management and also with ecosystems where soils and land cover are located. Thus, for example the ecosystems services of nutrient availability resulted better on those covers where fertilisers are applied and also there are practices orientated to improve soil fertility (Figure 3). In the other hand, ecosystems services such as water availability correspond to covers which are generating better conditions on soils hydraulic properties (Figure 4).

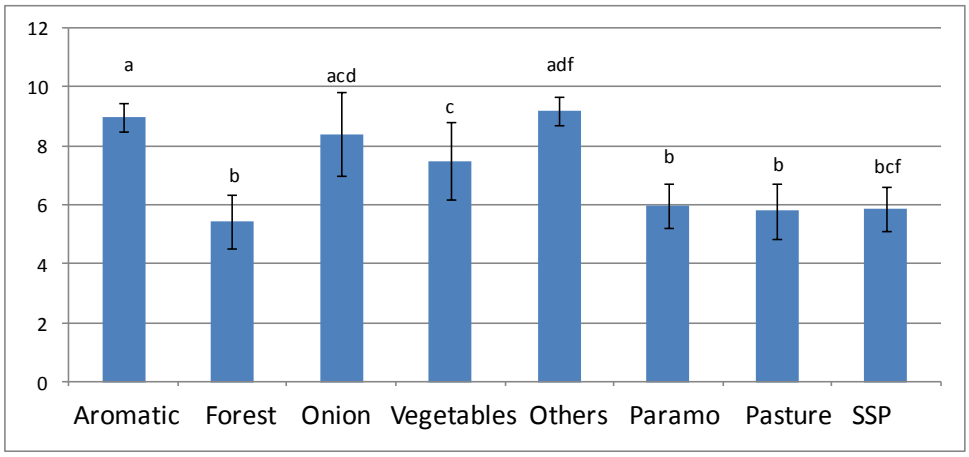

Figure 3. Ecosystems service of nutrient availability. SSP= silvopastoral systems;. Verticals lines on bars represent standard deviation. Dissimilar letters are statistically differences (P<0,05).

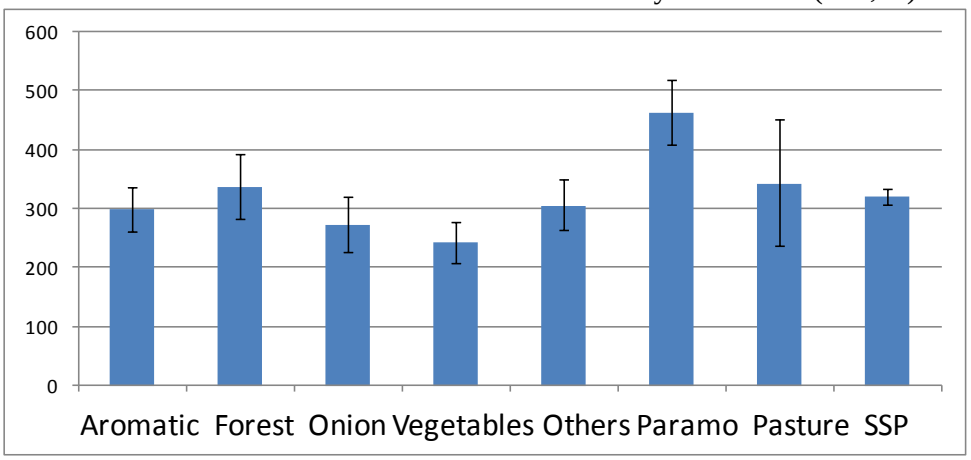

Figure 4. Ecosystems service of water availability. SSP= silvopastoral systems;. Verticals lines on bars represent standard deviation. Dissimilar letters are statistically differences (P<0,05).

Thereafter, information on carbon fixed by soils and ecosystems services provide by soils is being utilised by institutions and different stakeholder in charge of land planning and making decision for development plans.

Conclusions and Outlook

Carbon content in soils represents relevant information on the state of agroecosystems evaluated and contributes to glimpse which farming systems or cover could be better to avoid environmental degradation. Besides, also it is important as baseline information required in projects of voluntary carbon markets. Higher values of carbon content under cover like paramo show the importance of this ecosystem for climate change mitigation.

The approach for defining ecosystems services provided by soils is an important approach to encourage polices on the proper management of farming systems. At the moment, in processes on making decision this approach contributes to develop strategies for management agroecosystems.

Acknowledges

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