Mol2Net, **2016**, 2, Section M, *doi:* 10.3390/MOL2NET-02-M???
http://sciforum.net/conference/mol2net-02

MODEC International Workshop on Modelization and Multidisciplinary Sciences for Development of Natural Products and Agro-Industrial Processess in Ecuador Amazon region

SciForum Mol2Net

ENVIRONMENTAL IMPACT OF LIVESTOCK SYSTEMS IN THE ECUADORIAN AMAZON

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Received: / Accepted: / Published:

Abstract.
Converting natural ecosystems into livestock agroecosystems often reduces soil organic carbon content by decreasing its supply source, as well as by increasing erosion losses and organic matter decomposition rate. In this sense, this study aimed to evaluate carbon sequestration and soil structure in livestock systems at Ecuadorian Amazon. The study was carried out in livestock areas of the Pastaza province, under rainforest and livestock systems with and without trees. We collected disturbed an undisturbed soil samples within depths from 0-10 and 10-30 cm. From these samples, we determined total organic carbon and some structural indexes, such as bulk density and soil porosity. The results suggest that the land use with forest, sequestered more total carbon in comparison with non-trees management, with an average value of 515 Mg C ha^{-1}. The silvopastoral systems stored total average from 55 to 103 Mg C ha^{-1}, which was affected by the number of trees. The structural indexes showed suitable values in all land uses, highlighting the role of the organic matter as an enhancer of the soil structural conditions, which favors aeration, root penetration and a greater rainwater uptake.

Keywords: Carbon sequestration; agroforestry systems; ecosystem services; structural indexes.

1. Introduction

The Ecuadorian Amazon region represents 45% of Ecuador territory. It is one of the most important biosphere reserves and provides a complex network of ecosystem services. In tropical areas, the extensive conversion of forests to pasture lands and the expansion of the agricultural frontier might be identified as the most important promoters of land use changes. These facts lead to consequent loss of environmental quality and biodiversity (Vallejo-Quintero, 2013). The unsustainable use of soils in deforested area at the Amazonian border, is one of the greatest threats to the rainforest. Among the causes of soils degradation in humid tropics are phosphorus (P) depletion, decrease of soil organic matter (SOM) and the loss of basic cations

(Ferreira Aguiara et al., 2016). This scenario shows the extreme fragility and vulnerability of soil resource to degradation, deforestation and the advance of the agricultural frontier in the Ecuadorian Amazon, which are problems requiring evaluation (Bravo et al., 2015). Agroforestry systems are believed to have a higher potential to sequester C than pastures or field crops. For example, the estimates of carbon sequestration potential in agroforestry systems are highly variable, ranging from 12 to 228 Mg ha^{-1} (Mutuo et al., 2005; Dixon ,1995) and for the different carbon compartments such as aboveground biomass (70 Mg ha^{-1}) and soil (25 Mg ha^{-1}) (Jadan et al., 2012). As can be expected, these values are a direct manifestation of the ecological production potential of the system, depending on a number of factors including site characteristics, land-use types, species involved, stand age, and management practices (Ramachandran et al., 2009). In this context, the objective of this work was to assess the environmental impact of land use change on carbon sequestration and soil structure in livestock systems in an experimental area of Pastaza province at Ecuadorian Amazon Region.

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2. Results and Discussion

Structural parameters and carbon sequestration under different land uses systems are showed in Table 1. The results suggest that the soil use with forest, sequester more total carbon in comparison with management without trees, with average values of 515 Mg C ha^{-1}. The silvopastoral systems stored an average from 55 to 103 Mg C ha^{-1}, which were affected by the number of trees. As expected, these values are concomitants with ecological production potential of the system, depending on a number of factors including: site features, land-use types, species involved, stand age and management practices (Ramachandran et al., 2009).

The structural indexes presented suitable values in all land uses, highlighting the role of the organic matter as an enhancer of the soil structural conditions, which favors aeration, root penetration and a greater rainwater uptake. We elucidate that land use changes with the adoption of agroforestry systems (AFSs). Proper management practices promote carbon sequestration in both, soil and biomass in Amazon region. Our results reinforce the role of good soils structural conditions as regulator of the ecosystem and its contribution to the mitigation of global climate change (Lal, 2008).

Table 1. Structural parameters and carbon sequestration under different land uses systems.

	Land Use				
Structural parameter /Carbon Stock	AFSs GGWFT	AFSs GGWAT	AFSs DGWGT	AFSs MGWAT	Forest
Bulk density (BD)	0,33**b**	0,30**b**	0,91**a**	0,72**a**	0,56**b**
Total porosity (TP)	92,13**a**	88,02**a**	71,42**b**	78,39**b**	77,13**b**
Aeration porosity (AP)	14,94**a**	15,09**a**	16,20**a**	13,86**a**	18,29**a**
Retention porosity (RP)	77,19**a**	72,94**a**	55,22**b**	64,53**b**	58,84**b**
Soil C stocks	56,87**b**	56,89**b**	35,74**c**	58,30**b**	60,86**a**
Total biomass ha^{-1}	54,85**c**	82,41**b**	39,75**d**	58,56**c**	909,39**a**
Mg C in aboveground biomass Ha^{-1}	27,42**c**	41,20**b**	19,88**d**	29,28**c**	454,70**a**
Mg CO_2 Ha^{-1}	100,65**c**	151,22**b**	72,94**d**	107,46**c**	1671,12**a**
Total Carbon Stock	84,30**b**	98,08**b**	55,62**c**	87,58**b**	515,56**a**

Agroforestry systems (AFSs); GGWFT: Gramalote grass with few tree s; GGWAT: Gramalote grass with abundant trees; DGWT Dali Grass with Guayaba trees. Significant differences of the means according to Tukey's adjustment ($P< 0.05$) in the same row are indicated with different letters.

3. Materials and Methods

The study was carried out under livestock areas in Pastaza province, Amazon Region, Ecuador. The climate of this area is typical of an humid tropical forest, with average altitude within 500 and 900 m.a.s.l, average annual rainfall of 3500 mm, annual evapotranspiration of 150 mm, average annual temperatures within 23.4 and 25.4 °C and relative humidity of 87%. (Nieto and Caicedo, 2012). The assessed soils belonged to the *Inceptisols* (Soil Survey Staff, 2014; Nieto and Caicedo, 2012) order and are characterized by acidic conditions, low natural fertility, low potassium, calcium and phosphorus contents and high iron content. The forest and pastures systems, with and without trees, were compared among them. We collected disturbed an undisturbed soil samples at 0-10 and 10-30 cm depth. From these samples, total organic carbon (TOC) bulk density and soil porosity were determined. TOC was analyzed by Walkey-Black method (Nelson and Sommer, 1982), bulk density (ρ_s) by cylinder method (Blake and Hartge, 1986) and soil porosity by the tension table method (Pla, 2010).

4. Conclusions

Identifying potential land uses for carbon sequestration and enhancing soil structural conditions, can restore the functionality and productivity of the soil resource. These environmental services can reverse degradation due to land use changes, diminishing CO_2 emissions into the atmosphere and increasing soil water uptake as corrective measures to global warming.

Acknowledgments

Authors acknowledge to the Universidad Estatal Amazónica for the economic support given allowing the project execution.

Conflicts of Interest

The authors declare no conflict of interest”.

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