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ANALYSIS OF THE SUPERFICIAL EROSIVE PROCESS ON DIFFERENT VEGETATION COVERS IN THEAMAZON REGION

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ABSTRACT

In the Amazonian region, agriculture is rapidly replacing forest cover, leading tosoil loss and climate change. In order to determine if there is variation on soil erosion in different plantages being used today measurement of soil loss were taken at 70 pins in two experimental plots, each of 20m², in area planted with sugarcane and pasture, from 10/2018 to 03/2019 in the municipality of Capixaba, State of Acre, Amazonia. Student'st-test were applied to the data and the results show differences between the two plots (p-value <0.05). Higher erosion values were obtained in the pasture area (4.95 cm / m^2 and 4.99 cm / m^2) at the front and back of the pins, respectively, while on the sugarcane plot the values were 2.46 cm / m^2 at the back of the pins and 2.73 cm / m^2 at the front. The results also indicate that the methodology used is perfectly applicable to measure soil loss in different land uses in the Amazon environment, being practical and low cost.

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INTRODUCTION

In the last decade, concern has been growing over the increased rate of intensive deforestation to make way for agriculture in the Amazonian region. Deforestation has high potential to affect climate change, besides influencing fluvial dynamics due to the intensification of soil erosion contributing to land degradation (COSTA *et al*., 2003; ARIMA *et al*., 2005; D'ALMEIDA *et al*., 2007; COE *et al*., 2009; RIVERO *et al*., 2009; OLIVEIRA *et al*., 2018). The natural forest is mainly being replaced by cattle breeding, as a result of pressure for new areas of commercial agriculture (DOMINGUES and BERMANN, 2012; BOWMAN *et al*., 2012; NEPSTAD *et al*., 2014) which is supported by government policies for the area (CARVALHO *et al*., 2019). According to Schlickmann and Schauman (2007) the commercial bovine cattle herd in the region rose from 26.6 million to 70 million between 1990 and 2007, this being responsible for 75% of the deforestation in the Brazilian Amazon. Likewise, sugarcane plantation is increasingly in the region also supported by government policies, such as the repeal of Federal Decree 6.961, of September/2009, limiting the expansion of sugarcane plantations. Historically the agricultural sector in Brazil has been largely marked by the cycle of planting sugarcane to obtain fuel (ALFONSI *et al*., 1987; CÂMARA and OLIVEIRA, 1993). Although the Amazonian production of sugarcane intended to supply ethanol and meet sugar demands corresponds to only 1% of Brazil's total production (CONAB, 2018), it is becoming increasingly important to the economy of the region, which promotes the growth of its cultivation area at the expense of the forest (PEREIRA, 2010). In fact, interest in this crop in the state of Acre began with the construction of the Alcoobrás power plant, which was created to produce alcohol as fuel and is located at km 59 of the BR-317 highway, in the municipality of Capixaba / AC. The expansion area of the crop covers a radius of 30 km from the Alcoobrás plant, which is an economically feasible distance for both cultivation and transportation to the power plant (FARIAS, 2010). The power plant fell into decay in the late 1980s, but its operationalization has recently been reactivated with the main objective of intensifying local development through the practice of agriculture in already deforested areas occupied by pastures and *capoeiras*. The aim is to provide feasible jobs and income for the new generation, supplying the regional market, and to contribute to the reduction of deforestation pressures in the State of Acre. In 2010, the power plant and the surrounding sugar cane plantations covered an area of 2,769 ha, with a production of 107 thousand tons of sugarcane (IBGE, 2011) and increasing (CONAB, 2018). However, very little is known about the effects of these new types of surface cover on runoff, although, admittedly, agricultural areas generally show a tendency for soil erosion losses, especially in conventional tillage compared to areas covered by native vegetation (BARBOSA and FEARNSIDE, 2000). In the Amazonian region, Sorrenson and Montoya (1989, apud THOMAZ and ANTONELLI, 2008) found that in Bela Vista do Paraiso - PR, the conventional tillage of soybean / wheat succession recorded a soil loss of 25 tons / ha / year while under a no-tillage system, the losses were much lower (0.9 tons / ha / year). In the same area, much lower values of soil erosion have been recorded on pasture: 0.7 tons / ha / year (LEPSCH, 2002), from 0.06 to 0.23 tons/ ha / year (CASSETI, 1983), and 1.8 tons / ha / year (SORRENSON and MONTOYA, 1989); as has also been found more recently in the State of Acre by Santos (2013) and Santos and Augustin (2015). According to the United Nations Environment Program - UNEP (1991, apud SPERANDIO *et al*., 2012), there are indications that large, cultivated areas may become unproductive, or at least economically non-viable, if there are no mechanisms to hold land erosion at tolerable levels. In fact, recent numbers disclosed by the FAO (SARTORI *et al*., 2019, apud PANAGOS *et al*., 2019, p. 1) indicate worldwide soil erosion as responsible for "approximately $8 billion annual global loss of the Gross Domestic Product (GDP), reducing yields by 33.7 million tons, and increasing water abstraction by 48 billion m^3". These numbers validate previous studies showing that agricultural productivity is reduced to almost zero in about 20 million hectares each year, or if it does not reach this, it at least has its agricultural holding made economically non-viable due to the induced erosion and degradation (SPERANDIO *et al*., 2012). In Brazil, 600 million tons of agricultural soil is lost each year through erosion, generating an economic loss of around US $ 4 billion in nutrients (BAHIA *et al*., 1992; AMORIM, 2003; SPERANDIO *et al*., 2012), which indicates a need for studies to understand the different factors involved in the erosion process. There is also a need for its quantification in the Amazonian region, where livestock and monocultures, in this case sugarcane are alternatives to forest gathering and family farming, typical of the forest environment. New studies are fundamental because they can be used as a basis for the elaboration of measures aimed at maximizing the use of natural resources, while avoiding the negative effects of agribusiness, which is now considered an economically viable alternative in the region, and for which there is insufficient data available (BARBOSA and FEARNSIDE, 2000; BARRETO and SILVA, 2020). The objective of this study is to quantify erosive losses due to rainwater runoff in an Amazonian environment altered by sugarcane plantation and pasture to verify their sustainability in relation to each other. The chosen area is the Alcoobrás Settlement Project, in the municipality of Capixaba/AC, southwestern Amazon, where both plantations occur. The sugarcane being planted in the region with great economic success is S. *Officinarum* (L.), strong and tall grass of the genus *Saccharum* of Asian origin. It is the base species of breeding programs, as it has desirable agronomic characteristics such as succulent stem and high sucrose content, good broth purity and adequate fiber content for milling (CASTRO and KLUGE, 2001; MATSUOKA *et al*., 2002). The effects of these plantations remain little known and there is a lack of in-depth studies on their impact on the natural environment, especially given the evidence of susceptibility to erosion due to the presence of erosive forms in the area, such as grooves, ravines, and gullies, which are apparently related to differentiated land use.

The Study Area: The municipality of Capixaba has an area of 1,696 km², which is equivalent to 9.6% of the territory, and 1.03%, of the total area of the state of Acre (ACRE, 2000). The municipality is located at the following geographic coordinates: 10º11'39.98"and 10º42'47.12" south latitude and 67º35 '15.29"and 68º04'42.30" west longitude (Fig. 6). Its main village is just 77 km from the State capital Rio Branco. It is limited to the north by the municipalities of Rio Branco and Senator Guiomard and by the State of Amazonas; to the south by Bolivia; to the east by the municipality of Plácido de Castro; and to the west by the municipalities of Xapuri and Sena Madureira (BRASIL, 2007). The pilot research area is in the Alcoobrás Settlement Project, located at km 59 of the BR-317, Jarina 231, municipality of Capixaba/AC, southwestern Amazon (Fig. 6). The Alcoobrás Settlement Project was created through Ordinance No. 058, of the Regional Superintendence of INCRA in Acre (SR 14) on 11/24/1998, covering an area of 7,690.85ha with 434 families settled (FARIAS and ARAÚJO, 2011). It is an area with high rainfall rates. Based on the historical series of rainfall from 1970 to 2016, the rainfall station being located in Rio Branco / AC, it can be observed that in approximately 42% of the recorded period, the pluviometric indices are above 2,000 mm / year (Fig. 7). This was also verified in the years monitored (2018 and 2019) during this research, (2,043 mm and 2,400 mm, respectively), which can be assumed to have generated intense runoff activity, contributing to the occurrence of erosive surface processes caused by rainwater drainage. The climate of the region is hot and humid equatorial type, characterized by high temperatures, high rainfall, and high relative humidity (Fig. 7). The predominant soils are Argisols with textural B horizon and low clay activity, many of them presenting high saturation of aluminum, the soils being well drained and occurring in flat to smooth undulating relief. The predominant vegetation is open palm-fringed forest with sectionsof dense *ombrophylous* forest (ACRE, 2000; FIGUEIREDO and CARVALHO, 2006). In addition to being a representative sample, since it has homogeneous biophysical characteristics in relation to the rest of the region, the sampling area also presents a considerable increase of areas planted with sugarcane for the production of alcohol by Alcoobrás S/A. Evaluations of physical and environmental changes still require more complete and complex research than those addressed in the present study, so that they can reveal the extent to which such activity is truly sustainable from the point of view of the dynamics of surface processes and their effects on the environment.

METHODS AND PROCEDURES

Initial field trips were conducted to select an adequate, representative slope to be sampled for the research in the Alcoobrás Settlement Project, located in the municipality of Capixaba/ AC, in the eastern area of the state of Acre. After slope selection, several field-measurement analyses were carried out.

Slope measurements and installation of the plots: The procedure consisted of taking measurements along a transect line from the top-to-bottom of the slope starting with the azimuth, followed by recording the inclination with the help of a direct reading Suunto clinometer, 3 topographic poles of 2 m height, and a 100 m tape line at regular distances of 20 m, with true slope orientation, according to procedures recommended by Augustin (1979). The experimental plots were installed on the middle-slopes, because this is a segment that, admittedly, constitutes a zone of sediment transport (YOUNG, 1972; AUGUSTIN, 1979; 1995; BARBOSA and AUGUSTIN, 2000; MARCHIORO and AUGUSTIN, 2007) and has also been used as slope unit in recent studies on slope erosion (SANTOS, 2013; SANTOS and AUGUSTIN, 2015). The plots were installed according to the methodology of De Ploey and Gabriels (1980): 2 meters wide by 10 meters long, totaling 20m^2, one with pasture cover and the otherwith sugarcane, totaling two plots on the same slope, with very similar conditions, ranging from 4.5º almost at the slope top to 3º on the lower slope. After selection of the sampling plots, they were isolated with plain wire to prevent disturbance by cattle. The plot with sugarcane cover was prepared by planting 44 seedlings of approximately 80 cm high, in 30 cm deeppits, with a perpendicular length of 50 cm and longitudinal length of 90 cm, equidistant from each other. The pasture cover was located on the same slope, where pasture cover already existed.

Installation of erosion pins and precipitation monitoring: After the delimitation and isolation of the plots, the erosion pins were installed following the methodology of Cunha and Guerra (1996). A total of 140 pins were used, which were made using 6-meter rebar-type iron rods with a diameter of 2.5 mm, cut into sizes of 35 cm, with a total of 70 in each plot. To allow interpolation of the data, installation of the pins was equidistant with horizontal intervals of 50 cm and vertical intervals of 70 cm, with the distribution of 14 (fourteen) rows of 5 pins in each plot. The pins were buried at 15 cm from the surface of the ground, leaving 20 cm above the surface to enable measurement. Studies monitoring the erosive process require rainfall data, considering that in tropical humid environments water constitutes the main erosive agent, providing the loss of material and its deposition. In this case, it was necessary to install a Ville de Paris rain gauge to verify the actual precipitation on each plot, with values being recorded weekly during the 6 months of monitoring (October 2018 to March 2019), totalizing 20 weeks.

Erosion measurement procedures in the field: The sediment loss measurements were carried out weekly at each of the 70 (seventy) pins installed on each plot using a measuring tape and specific annotation sheet. The measurement procedure consists of positioning the measuring tape on the ground surface up to the top of the pin, at its front and atits back. This procedure aims to identify the influence of surface runoff on sediment removal down slope and to mitigate the effects of pin interference on the ground. Water infiltration in the soil was measured using a Hills infiltrator, according to the methodology of Cunha and Guerra (1996). Soil compaction was taken with an impact penetrometer, with the repetition of 20 (twenty) beats in each experimental plot, following Stolf´s (1983) methodology. For data treatment, the statistical software R® version 3.6.1, available on the internet (www.r-project.org) and the application of Student's t-test and Pearson's correlation (r) from Excel for Windows. The Arcgis 9.3 Geographic Information System was used for spatialization of the data for each plot, monitored through interpolation (IDW) of the values identified at each pin.

RESULTS AND DISCUSSION

During the monitoring period, the total recorded rainfall was 1333 mm and 1372 mm on the pasture and sugarcane plots, respectively. Losses on the plots were calculated by adding the loss values of all the pins. On the pasture it reached a total of 99 cm lowering at the front part of the pins corresponding to 4.95 cm / m^2) while a loss of 99.9 cm, corresponding to 4.99 cm / m^2, was found at the back of the pins for the six months of monitoring (October 2018 to March 2019). In the same period, in the area with sugarcane, a total lowering of 49.2 cm was measured at the back of the pins, corresponding to a loss of 2.46 cm / m^2, while a loss of 54.6 cm was recorded at the front of the pins, corresponding to 2.73 cm / m^2.

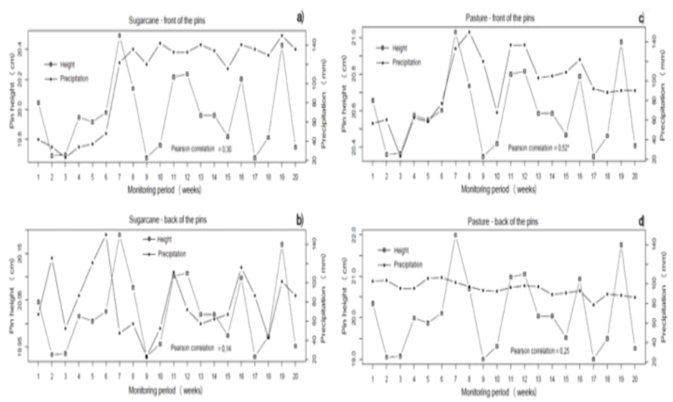


Figure 1. Correlation between the height of the pins and the total precipitation, per week, during the monitoring period

The losses, considering the front and back measurements at the pins, reached totals of 198.9 cm on the plot with pasture cover, which corresponds to 9.94 cm / m², and 103.8 cm for the plot with sugarcane, corresponding to5.19 cm / m². These results seem to be related to the occurrence of more concentrated runoff on the pasture and more diffuse runoff on the sugarcane plot, enabling the assumption that it occurs due to higher retention of sediment in the sugarcane tufts. This interpretation is reinforced by the fact that only the plot with sugarcane shows positive values of sediment deposition (0.1 cm and 1.9 cm). The correlation of rainfall totals with the total data of the pins indicates the highest frequency during the 7th week of monitoring (r = 0.50, r = 0.95), showing that with the increased precipitation of the rainy season there was greater surface flow and erosion. Pearson's correlation analysis for the data set, encompassing the entire monitoring period (20 weeks), shows a strong and positive correlation between precipitation rates and changes in the front pins of the plot with pasture (r = 0.52), as shown in figure 1c. In the other situations, although it presented weak positive correlations, the rainy period was demonstrated for the height of the pin (Fig. 1).

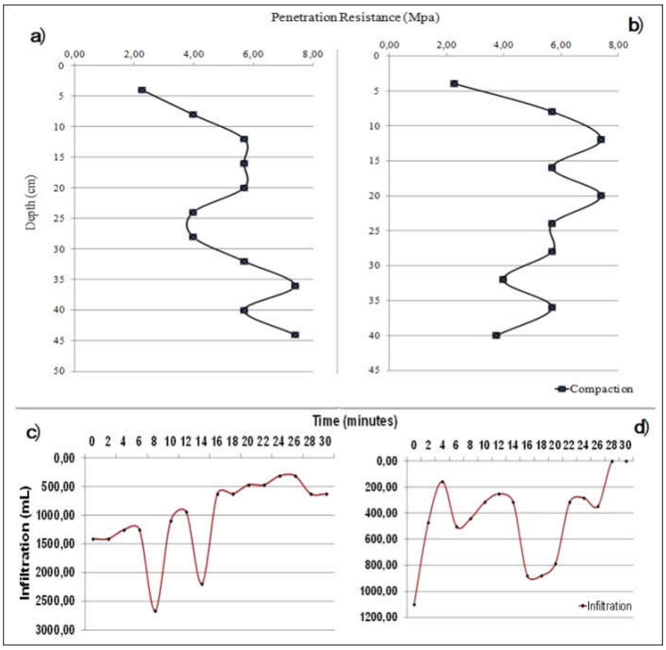


Figure 2. Compactation (Mpa) and Infiltration (mL/min) in the sugarcane plot ("a" and c) and in the pasture plot ("b" and "d") - (September/2013)

Legend: (A) general view of the vegetation cover in the sugarcane plot; (B) vegetation cover in the plot with pasture during the last month of monitoring (March 2014). It is possible to observe an increase in vegetation cover on both plots regardless of cover type in relation to the beginning of the monitoring period (October2018). Photos: N. Souza – Mar/2019.

Figure 3. Vegetation cover in both plots at the end of the monitoring period (October 2013 to March 2014)

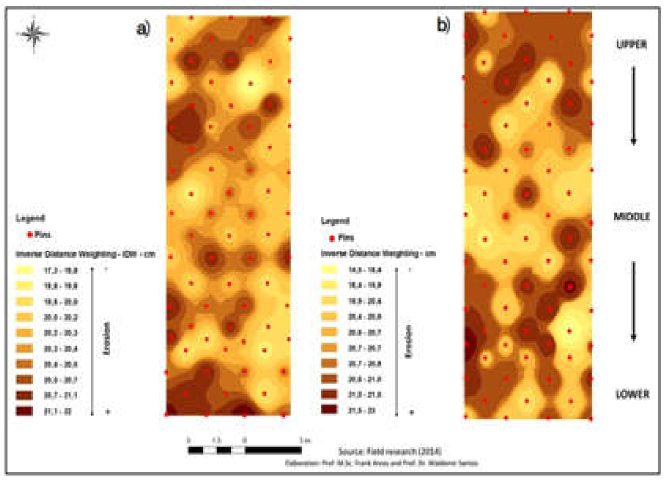


Figure 4. Spatialization of the results of sediment loss through runoff in the sugarcane plot (a) and pasture plot (b) at the front of the pins

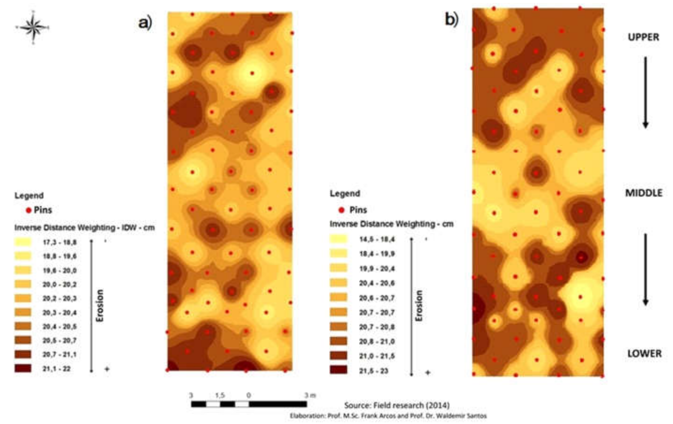


Figure 5. Spatialization of the results of sediment loss through runoff in the sugarcane plot(a) and pasture plot (b) at the back of the pins

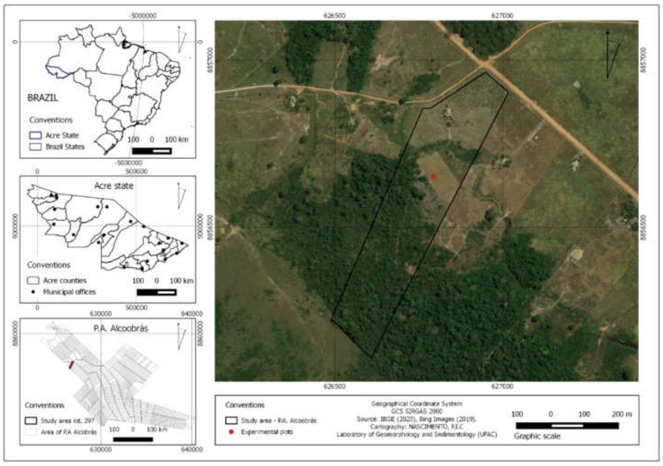
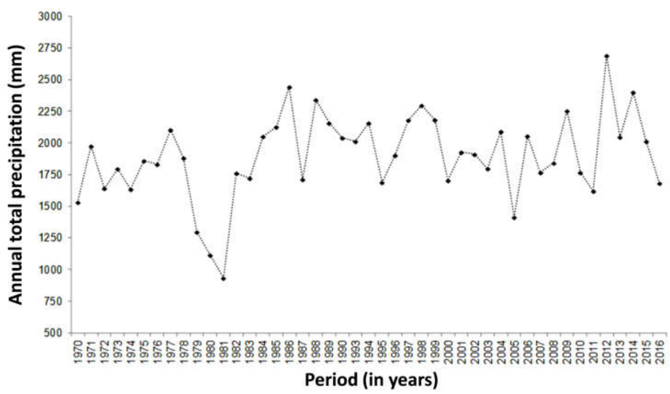


Figure 6. Location of the study area



Source: INMET (2016).

Figure 7. Total precipitation (mm) for the municipality of Capixaba-AC / 1970-2016

The results of Student's T-test indicate the presence of different behavior between the two plots in relation to lowering, with p-value <0.05, except for the 10th and 19th week, which is apparently related to the variation in rainfall intensity. Soil compaction was lower in the plot with sugarcane, reaching 5.68 Mpa at 12 cm (Fig. 2a), while in the pasture plot it reached 7.39 Mpa at the same depth (Fig. 2b). This characteristic of the soils may also have contributed to greater infiltration on the sugarcane plot and more intense flow on the pasture, as indicated by the results of the pins. On the plot with sugarcane, infiltration reached 1413 mL in the first 2 min of rainfall (September/2018), remaining high in relation to the pasture until 16 min, and stabilizing at 628 mL until the end of 30 min (Fig. 2c). On the pasture, during the first 2 min, infiltration reached 1099 mL, decreasing every 2 min, and stabilizing at 157 mL after 6 min (Fig. 2d). Results of infiltration tests show a higher infiltration rate on the sugarcane plot, which may also be related, among other factors, to the lower values of soil compactation (Fig. 2). In December, after two months of monitoring, rapid evolution of the vegetation cover was noticed on both plots, reaching 80 and 60% coverage on the pasture and sugarcane plots respectively (Fig. 3). From then on, the seasonal precipitation reached higher intensity, affecting the erosion capacity of the runoff on the plots. From December 2018 onwards, with the increase in the amount of rainfall, the soil lowering rates indicated by the pins also increase. Data shows that the lowering of the ground occurred mainly during the months of January and March/2019, which correspond to the periods with the highest rainfall values, thus establishing a direct correlation between rainfall concentrationand sediment loss, regardless of vegetation cover. It has been observed during the recorded period that rainfall intensity did not interfere in the percentage of ground vegetation cover, which reached 80% on the plot with pasture and 60% on that of sugarcane (Fig. 3). However, despite showing denser vegetation cover, the plot with pasture recorded higher values of sediment loss than that with sugarcane. The interpolation between the data on loss around the pins indicates that the effects of the erosive process inside the plots was not homogenous, showing different values of sediment loss and deposition, depending on the position in different sectors of the plot. Higher erosive losses were observed in the upper and lower sectors in both the sugarcane and pasture cover (Fig. 4) plots, while lower values were recorded in the central sectors, demonstrating higher erosion capacity of the runoff at the entrance and exit of the plot, as well as a trend towards more significant sediment retention in the intermediate portion. These results seem to reinforce the role of this segment as one of "sediment transit", confirming results already found in other studies (BARBOSA and AUGUSTIN, 2000; MORAES *et al*., 2015; BALDASSARINI and NUNES, 2018). The measurements obtained at the front of the pins in both plots with different covers show higher values of sediment erosion than those obtained at the back of the pins (Fig. 5). Although, as recorded, variations of these values are low, they confirm the tendency of more sediment deposition at the rear portion of the pins (Fig. 4). At some pins, the occurrence of higher individual values of erosive loss seems to be associated with the local presence of chaotic flow of surface runoff water around the pin, promoting more significant sediment removal. The arrangement of the pins in relation to the sugarcane and pasture tufts may also havecontributed.

CONCLUSION

Detailed research on the effect of runoff due to land use changes in the Amazonian region remains scarce and needs to be increased. Such studies are of fundamental importance for a better understanding of erosion processes in this environment since runoff erosion processes can trigger land degradation with loss of the capability of the soil to support agriculture or enable reconstitution of the rain forest. Data from the response of different types of land vegetation cover to soil erosion are, therefore, an *a priori* requisite to support policies of more efficient land management of future interventions. Based on the analysis of field data on two experimental plots with different types of land cover, pasture, and a no-tillage area of sugarcane, installed parallel to each other on the same slope to monitor soil loss due to runoff, it was possible to observe differences in the erosion and deposition values between them. Results showed that the plot planted with sugarcane presents a lower rate of sediment loss due to runoff than the pasture. The difference in the values seems to be associated with high soil compaction values in the pasture covered plot, which tends to hinder infiltration and favor concentrated surface flow. At the same time, sugarcane tufts tend to intercept water flow, inducing infiltration and decreasing superficial flow, leading to less sediment removal, enabling the retention of sediment being transported by runoff. Results also indicate that the methodology used for measurement and sampling is perfectly applicable to the Amazonian environment. Therefore, the method used to evaluate the loss of sediments by erosive process - Pin method - is considered adequate to evaluate soil losses in perennial and forest systems, being a practical and low-cost method. Monitoring of surface erosion processes is a critical step in the evaluation of erosion losses, considering that studies of this nature are non-existent within the framework of the settlement project and can serve as a basis for improving current land use in the region. However, such studies, remain scarce and need to be replicated to validate results for larger areas. Lack of such studies suggests the need to expand similar research to reach more significant temporal and spatial scales covering wider areas with a greater number of plots to enable better prediction of the impact of monocultures such as sugarcane and pasture on soil erosion in the southwest Amazon, specifically in the state of Acre. Finally, it is important to point out the contribution of the theoretic-methodological approach to understanding the effects of sugarcane and pasture in the state of Acre to define better orientated policies of land use and occupation based on scientifically proven bases.

REFERENCES

ACRE. Governo do Estado do Acre. Programa Estadual de Zoneamento Ecológico-Econômico do Estado do Acre. Zoneamento ecológico-econômico: recursos naturais e meioambiente: documento final. Rio Branco: SECTMA, 2000.

ALFONSI, R.R., PEDRO JÚNIOR, M.J., BRUNINI, O., BARBIERI, V. Condições climáticas para cana-de-açúcar. In: PARANHOS, S.B. (Coord.). Cana-de-açúcar: cultivo e utilização. Campinas: Fundação Cargill, 1987.

ARIMA, E., BARRETO, P., BRITO, M. Pecuária na Amazônia: tendências e implicações para a conservação. Belém: Imazon, 75, 2005.

AUGUSTIN, C.H.R.R. A preliminaryintegrated survey ofthe natural resourcesnear Alcantarilla, Southeast Spain. Master of Science Thesis. 1979. 243p. Department of Geography, University of Sheffield, Sheffield, UK.

AUGUSTIN, C.H.R.R. Geoökologische Studien im südlichen Espinhaçogebirge bei Gouveia, Minas Gerais, Brasilien unter besonder Berücksichtigung der Landschaftsentwicklung.PhD Thesis. 1995. 294p. Johann Wolfgang Goethe Universität Frankfurt a. M., Germany.

AMORIM, R.S.S. Avaliação dos modelos de predição de erosão hídrica USLE, RUSLE e WEPP para condições edafoclimáticas brasileiras. 2003. Tese Doutorado. Engenharia Agrícola. Universidade Federal de Viçosa, Viçosa, MG.

BAHIA, V.G., CURI, N., CARMO, D.N. Fundamentos de erosão do solo (tipos, formas, mecanismos, fatores determinantes e controle). Informe Agropecuário, Belo Horizonte, v. 176, nº 16, p. 25-31, 1992.

BALDASSARINI, J.S., NUNES, J.O.R. Estimation de laperte de sol par les processus érosifs avec la méthode de repères d'érosion dans les parcelles expérimentales d'exploitations agricoles de l'État de São Paulo. Confins Revista Franco-Brasileira de Geografia (PARIS), v. 1, p. 1-23, 2018.

BARBOSA V.C.C., AUGUSTIN, C.H.R.R. Estudo preliminar da variação de microformas e da cobertura vegetal na geração do runoff e perda de solo em vertente do município de Gouveia/MG. Geonomos, v.8, nº2, p. 1-7, 2000.

BARBOSA, R.I., FEARNSIDE, P.M. Erosão do solo na Amazônia: estudo de caso na região do Apiaú, Roraima, Brasil. Acta Amazônica, v. 30, nº4, p. 601-613, 2000.

BARRETO, P; SILVA, D. Will cattle ranching continue to drive deforestation in the Brazilian Amazon? Conference Paper, Research Gate, January 2010. Disponívelem: https://www.researchgate.net/publication/276206360. Acesso: 23 jan. /2020.

BOWMAN, M.S., SOARES-FILHO, B.S., MERRYA, F.D., NEPSTAD, D.C., RODRIGUES, H., ALMEIDA, O.T. Persistence of cattle ranching in the Brazilian Amazon: A spatial analysis of the rationale for beef production. Land Use Policy, v. 29, p. 558–568, 2012.

BRASIL. Ministério do Desenvolvimento Agrário. Plano Territorial de Desenvolvimento Rural Sustentável Território do Alto Acre e Capixaba – Estado do Acre. Brasília: Secretaria de Desenvolvimento Territorial – SDT, 2007.

CÂMARA, G.M.S., OLIVEIRA, E.A.M. (Eds). Produção de cana-de-açúcar. Piracicaba: FEALQ, 1993.

CARVALHO, W.D., MUSTIN, K., HILÁRIO, R.R., VASCONCELOS, I.M., EILERS, V., FEARNSIDE, P.M. Deforestation control in the Brazilian Amazon: A conservation struggle being lost as agreements and regulations are subverted and bypassed. Perspectives in Ecology and Conservation, v. 17, Issue 3, July–September 2019, p. 122-130.

CASSETI, V. Algumas considerações a respeito dos fenômenos pluvio-erosivos em Goiânia - Goiás. Boletim Goiano de Geografia, Goiânia, v. 3, nº1, p. 161-180, jan/dez 1983.

CASTRO, P.R.C., KLUGE, R.A. (Eds.). Ecofisiologia de culturas extrativistas: cana-de-açúcar, seringueira, coqueiro, dendenzeiro e oliveira. Cosmópolis: Stoller do Brasil, 2001. 138 p.

COE, M.T., COSTA, M.G., SOARES-FILHO, B.S. The influence of historical and potential future de forestation on the stream flow of the Amazon River-Land surface Processes and Atmospheric Feedbacks. J. Hydrol, v. 369, p.165-174, 2009.

COMPANHIA NACIONAL DE ABASTECIMENTO (CONAB). Acompanhamento da safra brasileira, v. 5 - SAFRA 2018/19 – nº 1 - Monitoramento agrícola – Cana-de-açúcar - Primeiro levantamento/ MAIO 2018.

COSTA, M.H., BOTTA, A., CARDILLE, J.A. Effects of large-scale changes in land cover on the discharge of the Tocantins River, southeastern Amazonia.J. Hydrol., v. 283, nº 1-4, p. 206-217, 2003.

CUNHA, S.B., GUERRA, A.J.T. (Orgs.). Geomorfologia: exercícios, técnicas e aplicações. Rio de Janeiro, Bertrand Brasil, 1996.

D'ALMEIDA, C., VÖRÖSMARTY C.J., HURTT G.C., MARENGO, J.A., DINGMAN, S.L., KEIM, B.D. The effects of deforestation on the hydrological cycle in Amazonia: a review on scale and resolution. Int. J. Climatol. 27:633–647, 2007.

De PLOEY, J., GABRIELS, D. Measuring soil loss and experimental studies. In: KIRKBY, M.J. & MORGAN, R.P.C. (Org). Soil erosion. London: John Wiley& Sons, p. 63-108, 1980.

DOMINGUES, M.S., BERMANN, C. O arco de desflorestamento na Amazônia: da pecuária à soja. Ambiente & Sociedade, v. XV, nº 2, p. 1 -22, mai-ago, 2012.

FARIAS, C.S. Manipulação do Território: o agronegócio e o campesinato na Amazônia. Campo-Território: Revista de Geografia Agrária, v. 5, nº 9, p. 51-70, fev., 2010.

FARIAS, C.S., ARAÚJO, J.J.C.N. O agronegócio da cana-de-açúcar no estado do Acre: o incentivo estatal, a questão do campesinato e as condições de trabalho. Trabalho Necessário, ano 9, 12, 2011.

FIGUEIREDO, S.M.M., CARVALHO, L.M.T. Avaliação da exatidão do mapeamento da cobertura da terra em Capixaba, Acre, utilizando classificação por árvore de decisão. Cerne, Lavras, v. 12, nº 1, p. 38-47, jan./mar., 2006.

Instituto Brasileiro de Geografia e Estatística – IBGE. Produção agrícola municipal 2010. Levantamento sistemático da produção agrícola e uso da terra no Estado do Acre. Rio de Janeiro: IBGE, 2011.

Instituto Nacional de Meteorologia - INMET. Banco de Dados Meteorológicos para Ensino e Pesquisa. Disponível em: <http://www.inmet.gov.br/portal/index.php?r=bdmep/bdmep> Acesso em 08 fev./2016.

LEPSCH, I.F. Formação e conservação dos solos. São Paulo: Oficina de Textos, 2002. 178 p.

MARCHIORO, H., AUGUSTIN, C.H.R.R. Dimensões de parcelas experimentais: influência do escoamento superficial e erosão do solo em Gouveia/MG. Geografias, v. 3, n. 2, p. 7-16, 2007.

MATSUOKA, S., MARGARIDO, L.A.C., LAVORENTI, N.A., ELIAS JÚNIOR, R., PINELL, D.M. Comportamento de variedades de cana-de-açúcar em um sistema orgânico de produção. In: Congresso Nacional da STAB, 8. Anais. Recife: 2002, p. 301-308.

MORAES, I.C., CORREA, E.A., COUTO JUNIOR, A.A., PINTO, S.A.F. Análise das perdas de solo em parcelas experimentais em pastagem no centro leste paulista. In: XXXV Congresso

Brasileiro de Ciências do Solo, 2015, Natal. Anais do XXXV Congresso Brasileiro de Ciências do Solo. Viçosa-MG: Sociedade Brasileira de Ciências do Solo, 2015, v. 35, p. 1-4.

NEPSTAD, D.L, MCGRATH, D., STICKLER, C., ALENCAR, A., AZEVEDO, A., SWETTE, B., BEZERRA, T., DIGIANO, M., SHIMADA, J., MOTTA, R.S., ARMIJO, E., CASTELLO, L., BRANDO, P., HANSEN, M.C., MCGRATH-HORN, M., CARVALHO, O., HESS, L. Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains. Science, v. 344, Issue 6188, p. 1118-1123, 2014.

OLIVEIRA, J.V., FERREIRA, D.B.S., SAHOO, P. K., SODRÉ, G.R.C., SOUZA, E.B., QUEIROZ, J.C.B. Differences in precipitation and evapotranspiration between forested and deforested areas in the Amazon rainforest using remote sensing data. Environmental Earth Sciences v. 77, p. 239- 253, 2018.

PANAGOS, P., BORRELLI, P., ROBINSON, D. FAO calls for actions to reduce global soil erosion. Mitigation and Adaptation Strategies for Global Change, p. 2. 2019.

PEREIRA, M.F.V. A inserção recente da cana-de-açúcar no sudoeste da Amazônia: novos indícios da instabilidade do território em Rondônia e Acre. Interações, v. 11, nº 2 p. 187-193, jul./dez., 2010.

RIVERO, S., ALMEIDA, O., ÁVILA, S., OLIVEIRA, W. Pecuária e desmatamento: uma análise das principais causas diretas do desmatamento na Amazônia. Nova Economia, Belo Horizonte, v. 19, nº 1, p. 41-66, janeiro-abril, 2009.

SORRENSON, W.J., MONTOYA, L.J. Implicações econômicas da erosão do solo e do uso de algumas práticas conservacionistas no Paraná. Londrina, IAPAR, Boletim Técnico nº 21, 110 p., 1989.

SPERANDIO, H.V., CECÍLIO, R.A., CAMPANHARO, W.A., DEL CARO, C.F., HOLLANDA, M.P. Avaliação da erosão hídrica pela alteração da superfície do solo em diferentes coberturas vegetais de uma sub-bacia hidrográfica no município de Alegre, ES. Semina: Ciências Agrárias, Londrina, v. 33, nº 4, p. 1411-1418, jul/ago, 2012.

STOLF, R., FERNANDES, J., FURLANI NETO, V.L. Penetrômetro de impacto, IAA/Planalsucar-Stolf. Recomendações para o seu uso. R. Stab., Piracicaba, v. 1 nº 3, p. 18 – 26, 1983.

THOMAZ, E.L., ANTONELI, V. Erosão e degradação do solo em área cultivada com erva-mate (*ilexparaguariensis*), Guarapuava – PR. São Paulo, UNESP, Geociências, v. 27, nº 1, p. 21-30, 2008.

SANTOS, W.L. Dinâmica hidroecogeomorfológica em bacia de drenagem: efeitos do uso e ocupação da terra no sudoeste amazônico – Acre – Brasil. Tese. (Doutorado em Geografia). Programa de Pós-Graduação em Geografia. IGC/UFMG: Instituto de Geociências da Universidade Federal de Minas Gerais, 2013.

SANTOS, W.L., AUGUSTIN, C.H.R.R. Water and sediment loss through runoff in areas of forest and pasture cover in southwestern Amazonia – Acre – Brazil. ZeitschriftfürGeomorphologie, v. 59, Suppl. 2, p. 023-039, 2015.

SCHLICKMANN, H., SCHAUMAN, S.A. Pecuária, desmatamento e desastres ambientais na amazônia. Revista Ciências do Ambiente, on-line, agosto, v. 3, nº 2, p. 64-73, 2007.

YOUNG, A. Slopes. Edinburgh: Oliver and Boyd, 1972.

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