Acta Agronómica
ISSN: 0120-2812
Universidad Nacional de Colombia Sede Palmira

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Acta Agronómica, vol. 67, no. 2, 2018, April-June, pp. 289-296
Universidad Nacional de Colombia Sede Palmira

DOI: https://doi.org/10.15446/acag.v67n2.66131

Acta Agron. (2018) 67 (2) p 289-296 ISSN 0120-2812 | e-ISSN 2323-0118 *https://doi.org/10.15446/acag.v67n2.66131*

Characterization and mapping of soil classes of the Lajeado Pessegueiro watershed in Santa Catarina, Brazil

Caracterização e mapeamento das classes de solos da microbacia Lajeado Pessegueiro, Santa Catarina, Brasil

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Rec.: 05.07.2017 Accep.: 31.07.0217

Abstract

Pedological surveys and physiographic characterization of a watershed are fundamental procedures for planning the soil use. Thus, the aim of this study was to characterize and map the soil classes of the Lajeado Pessegueiro watershed, located in Guarujá do Sul, Santa Catarina, Brazil. The types of land use and occupation, slope classes and physiography of the study area were delineated and described. Data were collected from 19 complete soil profiles and 9 extra samples. Physiographic analysis was performed using prior information on the photopedology of the terrain geomorphological characteristics, climatic conditions, vegetation, land use and geological conditions. The watershed has a predominant undulating relief (406.51 ha). The predominant land use is agricultural, with temporary annual crops (50.09%). The predominant physiography is colluvial erosional slope (35.53%), followed by erosional slope (27.13%), plateau slope (21.55%), alluvial colluvial valley bottom (10.51%) and erosional colluvial slope (5.23%). The soil classes found were Red Nitosols (37.54%), Haplic Nitosols (8.22%), Haplic Cambisols (35.20%), Fluvic Cambisols (3.92%), Red Argisols (10.09%) and Litholic Neosols (5.04%). The data showed the importance of using the physiographic analysis of the area with geoprocessing techniques, assisting pedological surveys with presentation through thematic maps. These maps serve as a base material in studies evaluating land uses, and those aiming to contribute to a better planning of soil use.

Keywords: Physiography; photopedology; geotechnologies; pedological survey; thematic maps.

Resumo

Os levantamentos pedológicos e a caracterização fisiográfica de uma microbacia são procedimentos fundamentais para o melhor planejamento da exploração do recurso solo. Objetivou-se realizar a caracterização e o mapeamento das classes de solos da microbacia Lajeado Pessegueiro, Guarujá do Sul, Santa Catarina, Brasil. Fez-se a delimitação e apresentação da área de estudo, dos tipos de uso e ocupação das terras, das classes de declividade e da fisiografia da área. Coletaram-se informações de 19 perfis de solo completos e mais nove amostras extras. A análise fisiográfica foi feita por meio do conhecimento prévio de fotopedologia das características geomorfológicas do terreno, das condições climáticas, da vegetação, do uso da terra e das condições geológicas. O relevo predominante da microbacia é o ondulado (406,51 ha). O uso da terra predominante é de culturas temporárias (anuais) com 50,09%. A fisiografia predominante é a encosta erosional coluvial (35,53%), seguido da encosta erosional (27,13%), encosta em patamar (21,55%), fundo de vale coluvial aluvial (10,51%) e encosta coluvial erosional (5,23%). As classes de solo encontradas foram Nitossolos Vermelhos (37,54%), Nitossolos Háplicos (8,22%), Cambissolos Háplicos (35,20%), Cambissolos Flúvicos (3,92%), Argissolos Vermelhos (10,09%) e Neossolos Litólicos (5,04%). Por meio dos dados gerados evidenciou-se a importância da utilização da análise fisiográfica da área junto às técnicasde geoprocessamento, auxiliando nos levantamentos pedológicos juntamente com a apresentação desses estudos através de mapas temáticos, servindo como material base para estudos de avaliação do melhor uso das terras, assim como estudos que possam contribuir para um melhor planejamento de uso do solo.

Palavras-chave: Fisiografia; fotopedologia; geotecnologias; levantamento pedológico; mapas temáticos.

Introduction

Dokuchaev's soil-related studies established the first soil pedology concept, originating the current pedology, which consist of studies on soil genesis, classification, and mapping (Ker, Curi, Schaefer & Torrado, 2012). Soil survey and mapping are required constantly and continuously by Brazilian planning agencies, due to its importance for monitoring the conditions of natural resources and planning a rational land occupation (Mendonça-Santos & Santos, 2003).

The Brazilian Soil Classification System (SiBCS), currently in its third edition, is used to classify soils in Brazil. SiBCS is a hierarchical classification system that aims to consolidate the taxonomic systematization that expresses the current knowledge on the discrimination of soil classes identified in the country (Embrapa, 2013).

Soil mapping, photointerpretation and physiographic analysis are accessible low-cost tools for generating this information (Dortzbach, Ribeiro, Bacic, Silva, Laus-Neto & Chanin, 2011). Remote sensing data and topographic attributes of digital elevation models are widely used for understanding spatial and temporal relationships between soil classes and landscape components (Minasny & McBratney, 2007).

Physiographic analysis relates the external properties of a sub-landscape with internal characteristics expressed in its soil profiles. Each physiographic unit has a recognizable and differentiable physiognomy compared with neighboring areas, showing patterns of soil associated with each sub-landscape (Souza & Jiménez-Rueda, 2007). It can be understood as the geography of soils because it focuses on the study of external characteristics of a landscape and its effect on soils (Epagri, 1997).

The physiographic characterization of a watershed is a fundamental procedure for elaboration and installation of infrastructure projects, and soil water exploration, since the information on the watershed runoff dynamics, and terrain morphology make it possible to minimize environmental impacts and natural disasters. These data also allow the identification of resource potentials and evaluation of the transformations occurring in the soil surface, aiming to develop management practices that consider environmental sustainability (Sordi, Vargas, Santo & Nascimento, 2012).

In this context, the aim of this study was to characterize and map the soil classes of the Lajeado Pessegueiro watershed, located in Guarujá do Sul, Santa Catarina, Brazil.

Material and methods

Study area

The Lajeado Pessegueiro watershed encompasses an area of 980.51 hectares. It is located in the extreme west region of the state of Santa Catarina (SC), Brazil, in the municipality of Guarujá do Sul (26°23'4"S, 53°31'15" W, and altitude of 707 m); between the municipalities of Princesa and São José do Cedro (Figure 1).

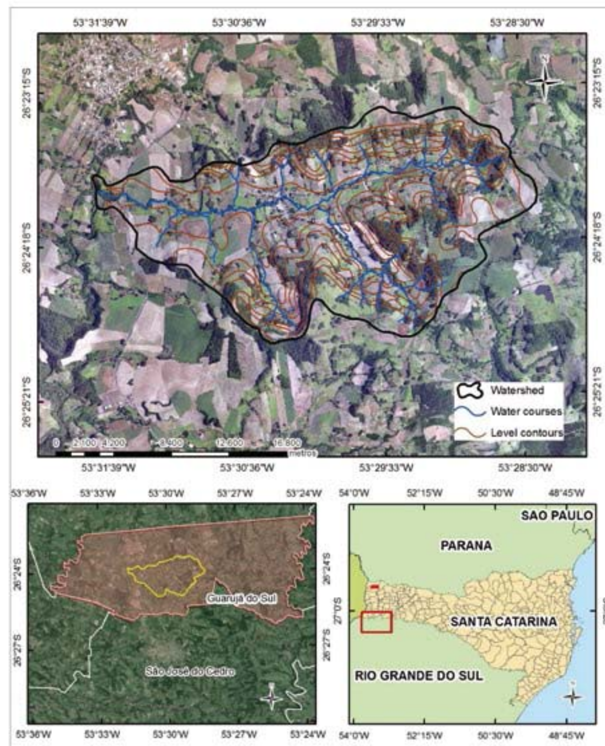

Figure 1. Map of the Lajeado Pessegueiro watershed, Guarujá do Sul, Santa Catarina, Brazil.

The economy of Guarujá do Sul is based on agriculture, which employs approximately 50% of the economically active population. Its land structure is characterized by small farms; 90% of farmers have less than 50 hectares, and use family labor (Icepa, 2005). The main agricultural activity of the 125 families living in the watershed area is the cattle raising for milk production, and cultivation of grains, especially maize (*Zea mays* L.) and soybean (*Glycine max* (L.) Merr.).

Regarding its geology, the municipality is located within the Serra Geral Formation, more precisely in the plateau escarpment modeled by effusive rock settlements, and sedimentary rock layers of the Paraná Sedimentary Basin belonging to the São Bento geological group, constituted mainly by volcanic rocks (Thomé, Zampieri, Braga, Pandolfo, Silva-Júnior, Bacic, Laus-Neto, Soldateli, Gebler, Ore, Echeverria, Mattos & Suski, 1999; Rocha, 2014). The climate of the region is Cfb, according to the Köppen classification, i.e., a constantly humid temperate climate with no defined dry season, and mild summer—average temperature of the hottest month < 22.0°C. It has annual rainfall of 1790 to 2280 mm, and relative air humidity of 73 to 82%. The waters of Guarujá do Sul are rich and well distributed; Guarujá do Sul is bathed by the rivers Flor, Arara, Tigre, Tracutinga, Pessegueiro, Maria Preta, Lageados, Taquaraçu, Della Flora, São Francisco, Sanga Mansa, Burro Morto and Tatu (Thomé *et al.*, 1999). The predominant forest formation in the region is Mixed Ombrophilous Forest (Santa Catarina, 1986).

Data acquiring, and tools used

Data and parameters were acquired from the soil survey conducted in the Lajeado Pessegueiro watershed through the project Participatory and On-Demand Survey, and Mapping of Soils and Land Use Suitability, developed by the Santa Catarina State Agricultural Research and Rural Extension Agency (Epagri), with support of the Brazilian National Council for Scientific and Technological Development (CNPq) (Notice 58/2010; Call 1-Technologic innovation).

This semi-detailed survey was carried out in April 2012, with information collected from 19 complete soil profiles plus 9 extra samples—28 observation points—and 1 point at the mouth of the Pessegueiro River without collection of soil samples for analysis. The criterion used to choose the collection points of soil profiles was the soil-landscape relationships, with the use of physiography and slope maps. This distribution have allowed a good representation of the soils occurring in the study area.

Information on the land use and occupation were also collected, quantified and plotted as a land use map. The land use of the watershed was determined according to the classes established by the IBGE (2013), through field recognition, information from farmers, and interpretation of aerial photos (scale of 1:25000) obtained by the Aero-photogrammetric Survey of the State of Santa Catarina in 2010/2011, available at the State Department of Sustainable Development (SDS/SC, 2011). These images were visually analyzed differentiating colors and textures, and the classes found were checked in the field—some of them confirmed with the producers, as in the case of fallow areas. The exposed soil class is represented by areas with shallow soils interspersed with rocks, which hinders the development of vegetation. The dirty pasture class is associated with the presence of indicating plants of incorrect management, showed by images of areas with rough texture. The capoeira class is represented by areas with secondary forests at initial stage of regeneration.

The delineation of the study area was performed from the main river's mouth, identifying the hydrographic network and the higher hills that surround the watercourses of the watershed. These identifications were performed through the interpretation of topographical maps and aerial photographs, and geoprocessing (Spanghero, Mellani & Mendes, 2105).

Prior information on the photopedology of the geomorphological characteristics of the terrain, climatic conditions, vegetation, land use, and geological conditions focused on the soil source material, was the base for the physiographic analysis of the watershed area applied to the soil survey. The material obtained in the aerophotogrammetric survey (aerial photos taken between 1978/1979 by the Cruzeiro do Sul Aerosurveys) was used in the preliminary photointerpretation, separating homogeneous surfaces and identifying sub-landscapes, which were later checked in the field.

A slope map was generated with the ArcGis® Slope tool. Topographic contours with scale of 1:50000 (IBGE, 2004) were used to generate a digital elevation model, which was used as input data in the Slope tool. After generating the raster format, it was reclassified according to the slope classes proposed by Embrapa (1995).

Soil classification was performed according to the Brazilian Soil Classification System (Embrapa, 2013), after characterization of soil profiles and interpretation of the soil physical and chemical data (Embrapa, 1997).

The mapping of soils, developed with the ArcGIS®-10.0 software, was carried out using maps of the IBGE/Epagri digital topography map collection (IBGE, 2004) with scale of 1:50000 (highways, springs, boundaries), and orthophotos with scale of 1:25000 obtained by the Aero-photogrammetric Survey of the State of Santa Catarina. The data on percentage of land use areas, slope, physiography, and soil classes were calculated using the Intersect tool (Geoprocessing) of the ArcGis® software.

The maps were plotted with scale of 1:35000 and minimum mappable area (MMA) of 4.9 ha, calculated by Equation 1.

$$MMA = \frac{E^2 \times 0.4}{10^8}$$

Equation 1

Wherein E is the scale.

Results

Slope classes in the watershed

Based on the material used, six slope classes were identified in the Lajeado Pessegueiro watershed (Figure 2), and the undulating relief was the most representative, with 41.45% of the area (406.51 ha), followed by the flat relief class, with 29.38% (288.04 ha), and the strong undulating relief with 19.76% (193.71 ha). The slightly undulating (8.14%; 79.78 ha), mountainous (1%; 9.84 ha) and steep (0.27%; 2.63 ha) classes were less representative.

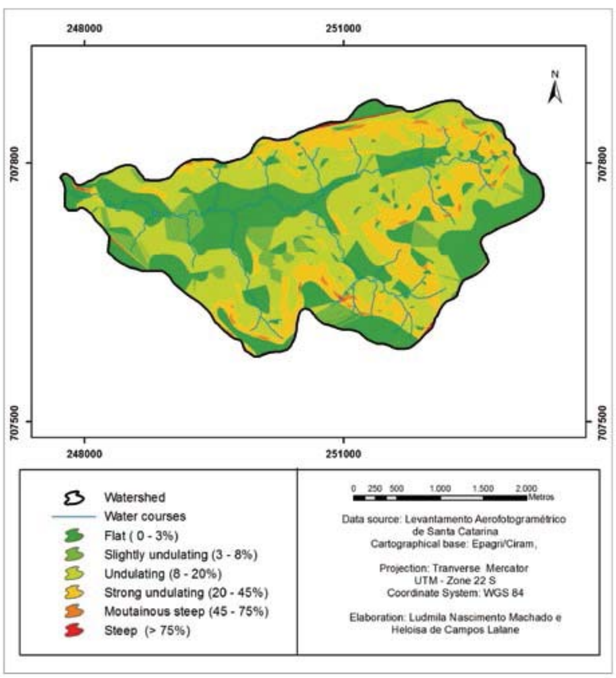

Figure 2. Slope map of Lajeado Pessegueiro watershed, Guarujá do Sul, Santa Catarina, Brazil.

According to the slope classes found, the area of the watershed presents restrictions for agricultural use, requiring the adoption of conservation practices of land use and management, especially for the undulating, and strong undulating relief classes. However, significant portion of its area presents high potential for agriculture, especially the flat, and slightly undulating relief classes.

Soil use and occupation in the watershed

The land of the watershed is predominantly occupied by temporary crops, mainly corn and soybean, totaling 491.15 hectares, representing 50.09% of its total area, which is 980.5 hectares (Figure 3).

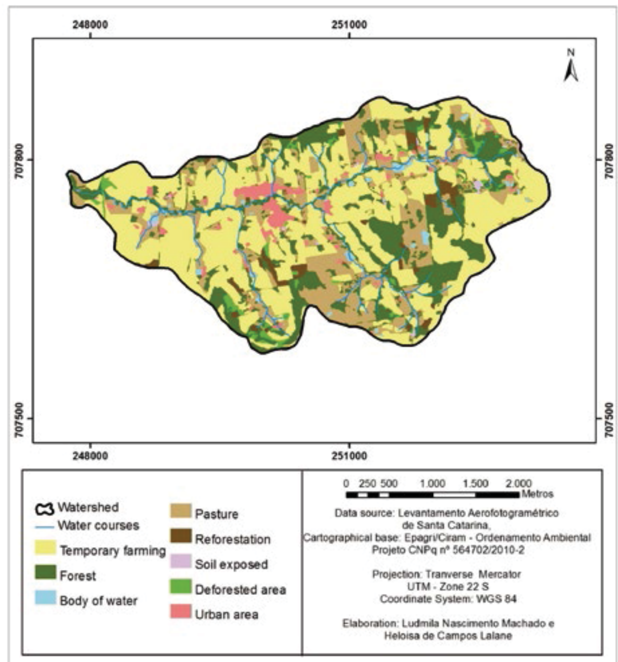

Figure 3. Land use and occupation map of the Lajeado Pessegueiro watershed, Guarujá do Sul, Santa Catarina, Brazil.

The watershed presents areas with forests (20.89%)—mainly in hilltops and areas with more pronounced slopes—few deforested areas (1.81%), and areas with exposed soil (0.41%). Areas with planted pastures, mainly ryegrass (*Lolium multiflorum* Lam.), occupy 19.69% of the watershed area; these areas are focused on dairy farming, which is the main local agricultural activity and is present in almost all properties of the watershed. However, the area used for this activity was not the most representative of the land use. Reforestation areas occupy 2.51%, represented by plantations of eucalyptus and pine. Water courses—rivers, dams, and springs—represent 1.11%, and urbanized areas, 3.49% of the total area of the watershed.

Watershed physiography

According to the physiographic analysis of the watershed, five sub-landscapes were observed:

erosional slope, colluvial erosional slope, plateau slope, erosional colluvial slope and alluvial colluvial valley bottom (Figure 4).

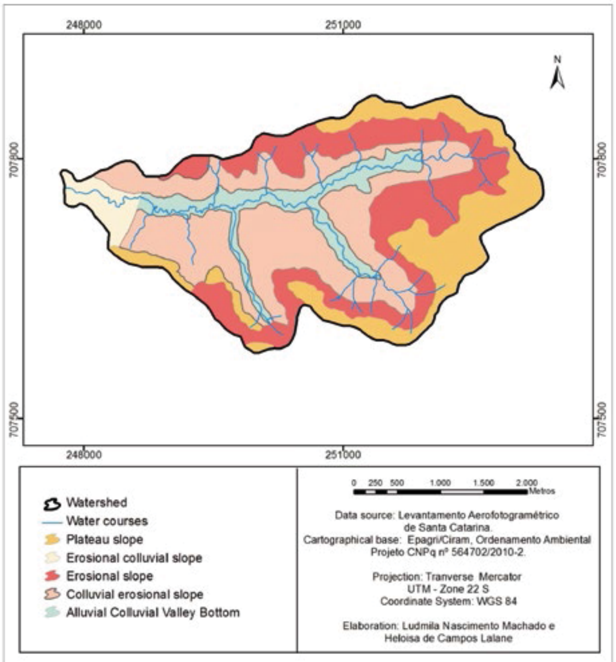

Figure 4. Physiographic map of the Lajeado Pessegueiro watershed, Guarujá do Sul, Santa Catarina, Brazil.

Plateau slopes are observed in the upper part of the watershed—higher hills that surround the watercourses—covering 21.55% of the watershed. This sub-landscape has slopes of 3% to 10%, and relief classes varying from flat to undulating (Figure 2). The predominant land use is agricultural, with annual crops (corn and soybean), and pastures (Figure 3).

Erosional slopes are located in the areas near the springs, below the plateau slopes, especially in areas with the highest slopes, showing strong undulating relief (Figure 2), and covering 27.13% of the watershed area. These areas are typically erosional, presenting constant processes of soil loss, especially in the few deforested areas (Figure 3). This sub-landscape have medium and steep ramps in strong undulating relief, with slopes of 20% to 45%. The land uses (Figure 3) of these erosional slopes (Figure 4) are predominantly pastures and forests, with few areas used for temporary crops—corn and soybean.

Colluvial erosional slopes are located just below the erosional slopes, representing the largest area (35.53%) of the watershed. Erosive (losses) and colluvial (accumulation) processes are predominant in this sub-landscape, determining its current physiography. The land uses (Figure 3) in these slopes is predominantly annual crops (corn, soybean, and oats), followed by some pastures. The undulating relief class was found in this sub-landscape (Figure 2).

Soil classification and mapping

The morphological descriptions and interpretations of the physical and chemical analyzes by the pedological survey made it possible to identify six mapping units in the study area, which are represented by the soil classes Haplic Cambisols, Fluvic Cambisols, Red Argisols, Red Nitosols, Haplic Nitosols and Litholic Neosols (Figure 5), according to Embrapa (2013).

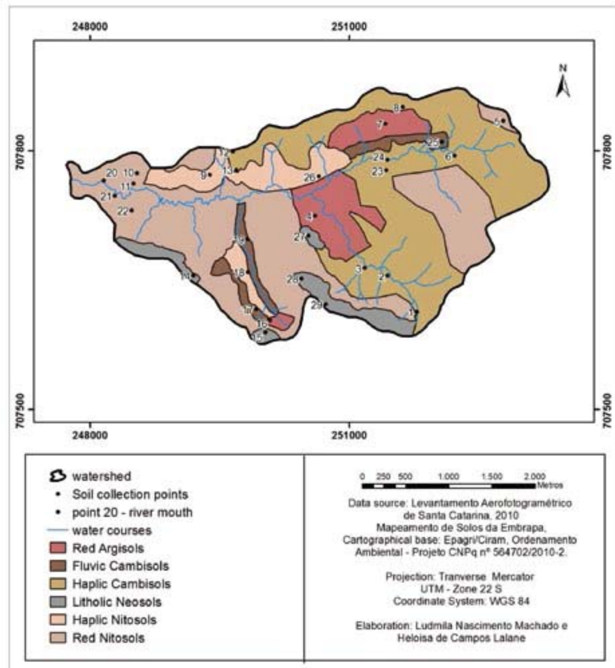

Figure 5. Soil map of the Lajeado Pessegueiro watershed, Guarujá do Sul, Santa Catarina, Brazil.

The overlapping of the physiography analysis (Figure 4) with the soil class distribution (Figure 5) showed the sampling and description of six soil profiles (P1, P6, P7, P8, P12 and P16) and an additional sample (P28) in the erosional slopes; with predominance of Haplic Cambisols (P1, P6, P8 and P12) and Red Argisols (P7 and P16) soils. Colluvial erosional slopes had 9 representative profiles (P2, P3, P4, P9, P13, P17, P14 and P26) and two extra samples (P23 and P27) sampled and described. The soils found in erosional and colluvial areas were Haplic Cambisols (P2, P3, P13 and P23), Haplic Nitosols (P9 and P26), Fluvic Cambisol (P17), Litholic Neosol (P27) and Red Argisol (P4). Four soil profiles were collected and described in the plateau slopes, and Litholic

Neosols (P14, P15 and P29) and Red Nitosol (P5) were found. Three representative profiles (P10, P11 and P21) and an extra sample (P22) were described and collected in the erosional colluvial slopes, and Red Nitosols were found in all profiles. Two soil profiles were collected and described in the alluvial colluvial valley bottom, which were represented by Fluvic Cambisols (P19 and P25).

A predominance of Nitosol and Cambisol soils were found, represented by 45.76% and 39.12% of the total area of the watershed, respectively (Figure 5). Red Nitosols (P5, P10, P11, P21 and P22), represented by 368.10 hectares of the total area, were the soils with high risk of erosion due to the rugged relief in which they are found. They are located mostly in the erosional colluvial slopes, and used mainly for agricultural crops and partly for pastures, and forests. Typical dystrophic Red Nitosol (P5, P21 and P22) and typical eutrophic Red Nitosol (P10 and P11) are found in this mapping unit. Points P11 and P22 were extra samples. These are well-drained soils with a high clay content in all horizons—predominant very clayey textural class—and, consequently, a textural gradient below 1.50. They present clays of low activity and can be dystrophic (P5, P21 and P22) and eutrophic (P10 and P11). The dystrophic ones have high aluminum contents, especially those in P5, P11 and P21 (Table 1).

Most of the Haplic Cambisols are present on the erosional slopes, and colluvial erosional slopes (Figure 3), areas of pronounced slopes that increase soil loss processes due to erosion. These slopes (Ee and Eec) are characterized by the presence of stones and low effective depth, typical characteristics of Cambisols. Areas with this type of soil were found with agricultural crops.

The mapping unit, characterized as Haplic Cambisols—345.1 hectares—is composed of typical eutrophic Ta Haplic Cambisol (P1, P2, P3, P6, P8, P12, P24 and P25) and typical eutrophic Tb Haplic Cambisol (P13). These soils occur in undulating to strong undulating relief. They are well-drained soils, with a moderate A horizon, with thickness of 8 to 58 cm, over an incipient B horizon; eutrophic along the profile due to a high base saturation (V%); medium texture, with high silt content—high silt to clay ratio—in all profiles; and high activity clay in all profiles, except in P13 (Table 1).

The mapping unit represented by the Red Argisol (P4, P7 and P16) had 98.9 hectares. This soil is predominant in erosional slopes and occurs partly in erosional colluvial slopes. The land use found for this class were agricultural crops, and pastures. This unit is composed by typical distrophic Red Argisol (P4), eutrophic Red Argisol (P7) and leptic eutrophic Red Argisol (P16).

The Argisols also presented a moderate A horizon, with thickness of 12 to 15 cm, over a textural B horizon with a textural gradient of 1.86 (P4), 1.97 (P7) and 1.76 (P16). These soils are located in undulating to strong undulating relief, are well drained, and present high contents of exchangeable aluminum and high activity clays (Table 1).

Table 1. Chemical characteristics of the soil profiles studied.

Soil profile	Soil Horizon	pH H_2O	Al	Ca+Mg	H+Al	K	P	OC	CEC pH7.0	CEC clay	V
				$cmol_c\ kg^{-1}$		mg kg^{-1}		g kg^{-1}	$cmol_c\ kg^{-1}$		%
P1-CX	A	5.30	0.1	13.7	3.16	276.2	4.8	17.40	17.57	------	82
	Bi	5.60	0.0	20.6	3.09	64.3	3.4	9.28	23.85	113.59	87
P2-CX	A	5.80	0.0	16.0	3.05	210.9	15.4	15.66	19.59	------	84
	Bi	6.00	0.0	14.5	2.40	88.1	3.3	11.02	17.13	146.38	86
P3-CX	A	5.00	0.3	15.8	4.16	62.4	0.16	15.66	20.12	-------	79
	Bi	6.20	0.0	22.5	2.99	33.7	0.09	10.44	25.58	82.24	88
P4-PV	A	5.20	0.2	8.8	3.27	54.50	0.14	17.40	12.21	------	73
	Bt	5.00	3.0	3.7	12.83	21.8	0.06	11.02	16.59	27.46	23
P5-NV	A	4.70	1.7	2.7	5.68	80.2	0.21	16.24	8.59	-------	34
	Bt	5.40	0.0	1.4	2.85	13.9	0.04	8.70	4.29	6.75	33
P6-CX	A	5.80	0.0	12.2	2.79	190.1	0.49	12.76	15.48	------	82
	Bi	5.80	0.0	11.7	3.02	112.9	0.29	13.34	15.01	54.98	80
P7-PV	A	5.90	0.0	17.5	2.72	49.5	0.13	14.50	20.35	-------	87
	Bt	4.90	1.4	12.1	4.78	22.8	0.06	9.28	16.94	33.67	72
P8-CX	A	5.4	0.0	9.9	2.57	239.6	0.61	15.66	13.08	------	80
	Bi	5.6	0.0	9.4	3.47	48.3	0.12	19.14	12.99	64.33	73
P9-NX	A	6.00	0.00	12.4	2.48	124.2	0.32	16.82	15.20	------	84
	Bt	5.80	0.00	7.4	2.99	31.1	0.08	13.34	10.47	31.44	71
P10-NV	A	4.9	0.3	7.9	3.8	53.5	0.14	19.72	11.84	-----	68
	Bt	6.4	0.0	9.8	2.4	18.7	0.05	19.14	12.25	20.76	80
P11-NV	A	5.2	0.30	7.1	4.51	196.4	0.50	17.98	12.11		63
	Bt	4.8	1.30	5.5	5.81	67.9	0.17	16.82	11.48	24.64	49
P12-CX	A	6.0	0.00	24.3	2.51	202.9	0.52	17.40	27.33	-----	91
	Bi	5.6	0.00	26.9	3.71	47.6	0.12	17.40	30.73	216.42	88
P13-CX	A	5.6	0.0	11.8	2.99	57.1	0.15	16.82	14.94	-----	80
	Bi	5.5	0.0	8.9	2.72	36.9	0.09	15.66	11.71	23.96	77
P14-RL	A	5.4	0.2	10.9	4.2	292.2	0.75	13.92	15.86	83.47	73
P15-RL	A	5.3	0.3	17.4	6.5	302.4	0.78	41.76	24.70	493.91	74
P16-PV	A	6.5	0.0	13.6	2.04	89.6	0.23	24.36	15.87	-----	87
	Bt	6.0	0.0	11.6	2.60	38.3	0.10	16.82	14.30	38.44	82
P17-CY	A	5.30	0.2	21.7	3.55	67.1	0.17	14.50	25.42	-----	86
	Bi	6.00	0.0	12.4	2.69	21.6	0.06	11.02	15.15	58.03	82
P18-NX	A	4.6	0.5	4.6	5.30	23.9	0.06	18.56	9.96	-------	47
	Bt	5.3	0.1	6.9	3.20	20.9	0.05	16.24	10.15	25.01	68
P19-CY	A	6.1	0.0	14.2	2.19	249.0	0.64	17.98	17.03	------	87
	Bi	5.9	0.0	12.4	2.88	50.6	0.13	15.66	15.41	87.56	81
	Cg	5.2	0.1	10.8	8.89	35.3	0.09	19.14	19.78	40.95	55
P21-NV	Ap	7.8	0.00	15.7	0.98	524.5	1.34	19.14	18.02	-------	95
	Bt	5.2	2.80	0.3	7.23	263.8	0.68	11.02	8.21	11.93	12
P24-CX	A	5.8	0.00	9.3	3.7	25.7	0.07	10.44	13.08	------	72
	Bi	5.4	0.00	8.6	3.6	19.3	0.05	8.70	12.28	41.21	70
P25-CY	A	5.9	0.00	13.4	3.7	25.7	0.07	16.82	17.18	-	78
	Bi	5.8	0.00	11.8	3.8	29.6	0.08	16.24	15.64	54.48	76
P26-NX	A	4.8	0.20	4.4	8.0	235.8	0.60	22.62	13.01	-------	38
	Bt	4.5	2.20	2.5	13.8	27.3	0.07	12.76	16.32	26.84	16

In P20 (River mouth), P22 (NV) and P23 (CX) no analyzes were performed, only field observations. P=profile, OC=organic carbon, CEC= cation exchange capacity, V%= base saturation, CX=Haplic Cambisol, PV=Red Argisol, NV=Red Nitosol, NX=Haplic Nitosol, RL= Litholic Neosol, CY= Fluvic Cambisol.

The mapping unit characterized as Haplic Nitosol (P9, P18 and P26) had 80.6 hectares of the watershed area. The typical eutrophic Haplic Nitosol (P9 and P18) and typical distrophic Haplic Nitosol (P26) are in this unit. These soils occur on colluvial erosional slopes in undulating relief. They are well-drained soils with moderate A horizon (P9 and P26) over a nithic B horizon, and humic A horizon in P18, but without retractile character. They present high contents of exchangeable aluminum in P18 and P26 (Table 1), and high clay content in all horizons—clayey to very clayey textural classes. These areas are mostly used for pastures, followed by agricultural crops.

The unit represented by the fragmentary eutrophic Litholic Neosol (P14, P15, and extra samples P27, P28 and P29) occupies 40.4 hectares (5.04%) of the watershed area. This class occurs in the plateau slope areas, which are the highest elevation areas of the watershed, predominantly used for pasture and partly used for agricultural crops. Points 27, 28 and 29 were extra samples collected with an auger. These soils are well drained, with moderate A (P14) and humic A (A15) horizons, followed by fragmentary lithic contact within 50 cm. The Neosols presented low contents of exchangeable aluminum. P15 presented the highest organic carbon (OC) content of all mapped soils of the watershed (Table 1).

The mapping unit represented by Fluvic Cambisols (P17, P19 and P25), occupies 38.4 hectares, and are found mainly in the alluvial colluvial valley bottom (P17 and P19), and partly in the colluvial erosional slope. This unit comprises the typical eutrophic Ta Fluvic Cambisol (P17 and P25) and the gleysolic eutrophic Ta Fluvic Cambisol (P19). These soils have a moderate A horizon with 9 cm (P19) to 51 cm (P17), over an incipient B horizon. Points 19 and 25 occur in the alluvial colluvial valley bottom, in flat to slightly undulating relief, with P19 poorly drained and P25 well drained. P25 is an extra sample acquired with an auger. These soils present irregular (erratic) distribution of clay with depth, defining a fluvic character in these profiles.

Discussion

Machado, Bacic & Loss (2015), quantified the production areas, such as pastures and crops, as well as the preserved forest areas of one of the 125 properties in the Lajeado Pessegueiro watershed, in a participatory study. This made it possible to calculate the values of the production areas and verify their adequacy to the Brazilian forest code (Law No 12,651, May 25, 2012). This quantification was then performed in the 125 properties of the watershed, through the project Participatory and On-Demand Survey, and Mapping of Soils and Land Use Suitability. In general, the farmers in the watershed are worried about the current legislation, trying to preserve the remaining forest areas of their properties, avoiding deforestation, and giving attention to the soil use to prevent erosion processes.

Sub-landscapes represent the divisions and subdivisions of a physiographic landscape, or the dismemberment of a toposequence into sections. The criteria used in the photointerpretation considered geomorphological processes currently acting on the landscapes, partially modifying them (Epagri, 1997).

The sub-landscape described as erosional colluvial slopes covers 5.23% of the watershed area. The physiographic analysis performed by Dortzbach *et al.* (2013), also found this type of sub-landscape as the smallest areas of the watershed, formed by the gradual deposition of sediments released by rainfall erosion and laminar erosion, and dragged down the slope by gravity. The relief observed in this sub-landscape varies from flat to slightly undulating (Figure 2); and annual crops (corn and soybean), and pastures were the land uses found (Figure 3).

The alluvial colluvial valley bottom is located in areas of lower elevation and slopes, occurring in 10.51% of the watershed area. Flat relief is predominant in this sub-landscape (Figure 2); and its land use is composed of pastures, and annual crops (corn and oats) (Figure 3). The mouth of the Rio Pessegueiro is in this sub-landscape, at an altitude of 685 m.a.s.l.

The use of physiographic analysis contributed to the understanding of the genesis and evolution conditions of the landscapes, which are connected to pedogenetic processes. The boundaries of the soil classes were identified in each physiographic unit, and the individualization and spatializing of the soil classes were performed, allowing the recognition of the soil types associated to each physiographic unit (Villota, 2005).

The results showed the importance of using the physiographic analysis of the area together with geoprocessing techniques, in order to assisting in pedological surveys presented through thematic maps, serving as a base material in studies evaluating land uses, and those aiming to contribute to a better planning of soil use.

Conclusion

The watershed has predominance of undulating relief, followed by flat and strong undulating relief. The land of the watershed is predominantly used for temporary (annual) crops, followed by forests, and pastures. The predominant physiography in the watershed is the colluvial erosional slope, erosional slope, plateau slope, alluvial colluvial valley bottom and erosional colluvial slope. The soil classes occurring in the watershed were Red Nitosols, Haplic Nitosols, Haplic Cambisols, Fluvic Cambisols, Red Argisols and Litholic Neosols.

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