

**Granulometry and stability of aggregates in different land uses in the Santa  
Catarina Plateau of Southern, Brazil**

**Abstract:** The aim of the present work was to determine the granulometry and stability of aggregates in different types of land use in the Santa Catarina Plateau of southern, Brazil. The research was conducted on Capão Alto, Santa Catarina, Brazil. The land use types selected were natural forest (NF), stand pinus (PP), crop-livestock integration (CLI), and burned natural rangeland (BR). The definition of the collection points in the field was performed by means of a random sample survey, with nine sampling points by type of use. The stability of aggregates in water, expressed by the mean geometric diameter of aggregates (MGD), was performed after separation of the larger aggregates in smaller aggregates by a set of sieves with 8 and 4.76 mm. Subsequently, these aggregates were fractionated by means of a set of sieves of 4.76; 2.00; 1.00; and 0.25 mm by means of shaking submerged in water. The levels of sand, silt and clay presented differences between the types of land use. MGD ranges from 4.43 to 5.70 mm in NF; from 4.06 to 5.81 mm in PP; from 3.00 to 5.45 mm in CLI; e 4.35 to 5.57 mm in BR. In general, the results showed that MGD varied little in the different types of use, and in all treatments there was a trend of decreasing soil MGD with increasing depth.

**Key words:** Soil quality; Forest; Pinus; Crop-livestock integration; Burned natural rangeland.

## 26    **1. Introduction**

27        The degradation of the physical properties of the soil is one of the main processes  
28 responsible for the loss of its quality [1]. Soil cultivation changes its properties,  
29 especially when compared to the natural condition of fields or forests. Such changes are  
30 more pronounced in systems with intensive preparation, which are manifested in the  
31 stability of the aggregates, influencing the infiltration of water, soil erosion and plant  
32 development [2]. The stability of aggregates depends, mainly, of soil texture, of its  
33 mineralogy, the content and type of organic matter and the soil moisture [3].

34        The texture of the soil, that is, the distribution of the size of the solid particles,  
35 comprising the fractions sand, silt and clay, is an intrinsic property of the soil,  
36 dependent on the characteristics of the originating material and the natural agents of  
37 formation [4]. Of the many factors that affect soil water retention and its availability to  
38 plants, the main one is the granulometry, because it determines the proportions of pores  
39 in different sizes. As for erosion, the coarse sand and the clay are the fractions that offer  
40 greater resistance. By virtue of its diameter, the sands have a larger mass, which hinders  
41 the action of water, while the clays, due to its cohesion, especially when combined  
42 organic matter form stable aggregates, which also offer resistance to water action [5].

43        The soil structure is one of the most important attributes from the agricultural  
44 point of view, because it is related to the availability of air and water to the roots of  
45 plants, with the supply of nutrients, with the resistance to mechanical penetration of the  
46 soil, and with the development of the root system. Because of that, the maintenance of a  
47 good state of aggregation and stability, and consequently, of a good structure, is an  
48 essential condition to guarantee high productivities [6].

49       The study of changes in soil structure and aggregation, induced by its use,  
50       assumes relevant importance in forecasting these changes, with the purpose of  
51       subsidizing the adoption of a management system, which aims to maintain or recover its  
52       agricultural and productive potential [7]. In this context, the stability of aggregates can  
53       be used to evaluate the effects of different uses and management on soil quality [8].  
54       This quality indicator refers to the arrangement of solid particles in the formation of  
55       aggregates. A soil is considered to be of good structural quality when well aggregated,  
56       because it is a primary factor to improve soil permeability to water, causing better  
57       conditions for aeration and penetration of the roots and, as a consequence, increase in  
58       agricultural productivity [6].

59       Soil and crop management, including species with different root systems, has  
60       great influence on the stability of soil aggregates. The effects of plants can be direct or  
61       indirect, mainly by the action of protection of the superficial aggregates. In the present  
62       study, the presence of organic matter on the surface or in the soil by the action of the  
63       root system [9]. In view of the above, the objective of the present work was to  
64       determine the granulometry and stability of aggregates under different types of land use  
65       in the Santa Catarina Plateau of southern Brazil.

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## 68   **2. Materials and methods**

69       The experiment was carried out in a rural property in the municipality of Capão  
70       Alto, SC, located between 27°55 ' to 27°57'S and of 50°25' to 50°29'W. The local  
71       climate, according to the climatic classification of Köppen, is mesothermal humid

72 subtropical (Cfb), presenting average temperature of 14 °C and average altitude of  
73 approximately 1,022 m [10]. The predominant soil type is a Nitossolo Bruno [11].

74 The work consisted in the evaluation of four types of land use: a) Natural forest  
75 (NF), classified as mixed ombrophilous forest; b) *Pinus taeda* stands on first cycle of  
76 cultivation (PP), that was 8 to 10 years old. Previously these lands were occupied by  
77 natural field pasture and cattle; c) Crop-livestock integration (CLI). These lands were  
78 cultivated for 10 years under conventional tillage. For 8 years the annual cultivation has  
79 been carried out under direct sowing, without the stirring of the soil, with corn / soybean  
80 succession in spring-summer and under grazing with oats and ryegrass in autumn-  
81 winter; d) Burned natural rangeland (BR), in traditional extensive form for more than 70  
82 years. The land is burnt and then grazed with cattle. With this type of use, the field is  
83 burned every two years.

84 The collections occurred between September 2012 and April 2013. The definition  
85 of the field collection points was done by means of a random sample survey, with nine  
86 sampling points by type of use. Non-preserved soil samples were collected at four soil  
87 depths (0-5, 5-10, 10-20, and 20-40 cm), with the aid of a cutting blade. Posteriorly,  
88 they were dried, twisted and sieved with a 2 mm mesh opening, where soil size (clay,  
89 silt and sand) was determined according to the methodologies described in [12].

90 The stability of aggregates in water, expressed by the mean geometric diameter  
91 of aggregates index of the aggregates (MGD), was performed after separation of the  
92 larger aggregates in smaller aggregates by a set of sieves with 8 and 4.76 mm mesh.  
93 Posteriorly, the aggregates were fractionated by means of a set of sieves of 4.76; 2; 1;  
94 and 0.25 mm of mesh opening by means of submerged stirring in water. The material

was dried in an oven at 105 ° C and determined its mass according to Yoder [4], described by the equation below:

$$MGD = EXP \sum_{i=1}^n \left( \frac{AGRi * Ln * ci}{TAGR} \right)$$

AGRi represents the mass of aggregates in each class (g); TAGR is the aggregate mass of the initial sample (g); ci is the mean diameter of the class of aggregates i (mm); Ln is the Neperian logarithm.

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The data were analyzed through descriptive statistics (means of the points sampled) and the confidence interval of the means (CI) at the level of 10% of error probability.

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### 3. Results and discussion

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#### 3.1 Analyze granulometric

The mean values and confidence intervals of the particle size analysis are shown in Table 1. The content of sand, silt and clay presented differences between the types of land use. The sand contents varied from 50 to 62 g kg<sup>-1</sup> in NF; from 41 to 59 g kg<sup>-1</sup> in PP; from 33 to 54 g kg<sup>-1</sup> in CLI; and 41 to 65 g kg<sup>-1</sup> in BR. In general, the values presented a small variation among the types of land use, the confidence interval (CI) being similar between them, with the exception of CLI and BR for the 20-40 cm layer.

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**Table 1 - Mean values and confidence intervals of sand (g kg<sup>-1</sup>), silt (g kg<sup>-1</sup>) and clay (g kg<sup>-1</sup>) in different types of use and depth of land**

Layer (cm)	NF	PP	CLI	BR
Sand (g kg <sup>-1</sup> )				
0-5	62± 21	55 ± 14	54 ± 16	63 ± 12
5-10	61± 20	59 ± 17	46 ± 8	65 ± 31
10-20	50± 16	45 ± 10	38 ± 10	40 ± 9
20-40	52± 17	41 ± 8	33 ± 6	47 ± 9
Silt (g kg <sup>-1</sup> )				
0-5	572 ± 28	411 ± 61	345 ± 24	362 ± 19
5-10	536 ± 35	408 ± 76	338 ± 26	331 ± 29
10-20	497 ± 69	388 ± 74	331 ± 19	387 ± 43
20-40	464 ± 62	334 ± 44	271 ± 22	273 ± 46
Clay (g kg <sup>-1</sup> )				
0-5	366 ± 33	534 ± 60	601 ± 24	575 ± 19
5-10	403 ± 36	533 ± 76	616 ± 24	604 ± 17
10-20	453± 70	567 ± 77	631 ± 24	573 ± 38
20-40	484± 61	625 ± 44	696 ± 21	680 ± 42

NF – Natural forest; PP - Pinus stand; CLI – Crop-livestock integration; BR - Burned natural rangeland

Mean ± confidence interval ( $p \leq 0.10$ ). Means where the confidence limits overlap, are not significantly different.

123 The highest contents of silt were found in the NF, in all evaluated strata, without  
124 affinity with another type of use. The PP and CLI presented similar IC. According to  
125 [13], studies have found that, about six thousand years ago, there was a more humid  
126 period in the southern region of Brazil, which allowed the best adaptation of the  
127 araucaria forest that advanced on the fields. As vegetation is one of the soil formation  
128 factors, it is believed that the mixed ombrophilous forest may have influenced the  
129 granulometry of the soil in the areas where it is located, over these thousands of years.

130 The clay contents ranged from 366 to 484 g kg<sup>-1</sup> in NF; 533 to 626 g kg<sup>-1</sup> in PP;  
131 601 to 696 g kg<sup>-1</sup> in CLI and 575 to 680 g kg<sup>-1</sup> in BR. The highest clay content, in all  
132 layers, were found in CLI, being the lowest in the NF, without any similarity to any  
133 other mode of use through the confidence interval (CI), with the exception of PP that  
134 showed similarity with the CLI in the 10-20 cm layer. In average layers, the clay  
135 content was 24.3% lower in the NF in relation to the other uses and, in general,  
136 increased in depth for all types of use, which also occurred in studies by [14 and 15].

137 According to [16], the granulometry is considered a stable characteristic in the  
138 soil and of this form, it is not subject to change in a short time or depending on the type  
139 of use and handling. However, erosion can affect grain size, resulting in reduced soil  
140 productive capacity and nutrient loss [17].

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### 142 **3.2 Stability of aggregates**

143 The mean geometric diameter of aggregates (MGD) ranged from 4.43 to 5.70 mm  
144 in the NF; from 4.06 to 5.81 mm in PP; of 3.00 to 5.45 mm in the CLI; and from 4.35 to  
145 5.57 mm in the BR (Table 2). According to Bertol et al. [2], the stability of the structure

varies with the intrinsic soil conditions and with the management and cultivation systems.

**Table 2 - Mean values and confidence intervals of the mean geometric diameter - MGD (mm) of the soil aggregates in the different types of use and in the different depths**

Depth	NF	PP	CLI	BR
(cm)	MGD (mm)			
0-5	5,70 ± 0,44	5,81 ± 0,27	5,45 ± 0,23	5,54 ± 0,38
5-10	5,25 ± 0,83	5,63 ± 0,27	5,41 ± 0,24	5,57 ± 0,22
10-20	5,18 ± 0,96	5,00 ± 0,89	4,55 ± 0,78	5,39 ± 0,41
20-40	4,43 ± 0,91	4,06 ± 0,83	3,00 ± 0,46	4,35 ± 0,32

NF – natural forest; PP - pinus stand; CLI – Crop-livestock integration; BR - Burned natural rangeland

Means ± confidence interval ( $p \leq 0.10$ ). Means where the confidence limits overlap, are not significantly different.

At the depth of 0-20 cm, all types of land use presented similarity considering the CI. The same occurred in [7], where the stability of aggregates also did not change between uses at this depth. [8], evaluating the stability of aggregates of a Red Dystrophic Latosol under different uses, also did not find significant differences between treatments.



163 In contrast, according to [2], an aggregate of high average diameter does not  
164 always present adequate distribution of pore size in its interior, which implies in  
165 variable structural quality. What, according to [18] can be seen in degraded pastures,  
166 where physical degradation is observed, evidenced by high densities, even though it  
167 presents high stability of aggregates. In this context, macroaggregates formed by  
168 physical processes, by means of mechanical operations of machines or equipment or by  
169 the trampling of animals, may not be stable.

170 At depth of 20-40 cm, CLI had the lowest MGD value. This behavior can be  
171 attributed to soil disaggregation when submitted to conventional tillage, which  
172 consequently reduces the carbon stock and the stability of aggregates, compared to other  
173 types of use. For example, Martins et al. [19], studying the effect of deforestation and  
174 cultivation, in the physical characteristics of the soil, pointed out that the stability of  
175 aggregates is strongly affected by the removal of vegetation and subsequent exposure of  
176 the soil to the warming and the impact of the rain drops. Mota et al. [14], evaluating the  
177 physical quality of a Cambisol, observed that under native forest greater stability of  
178 aggregates was verified when compared to the areas under cultivation. The authors [20,  
179 21, 18, 22, 23], also found greater stability of aggregates in natural forest compared to  
180 other types of uses. According to Salton et al. [18], management systems that provide  
181 more robust aggregates are desirable, because they will maintain the structure of the soil  
182 without major changes when submitted to external forces, such as animal trampling and  
183 mechanized operations, besides greater resistance to erosion losses.

184 In all types of land use there was a tendency for soil MGD to decrease with  
185 increasing depth, which may have occurred by reducing organic matter in deeper layers.  
186 In general, the results showed that MGD varied little in different types of use.

187 According to Demarqui et al. [24], the aggregation and stability of soil  
188 aggregates depend on some of their physical and chemical properties, especially organic  
189 matter, clay minerals and iron and aluminum oxides. In this context, probably the  
190 natural soil conditions (clayey to very clayey textural class with high levels of organic  
191 matter and oxides) exerted greater influence on the stability of aggregates than the type  
192 of land use.

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#### 195 **4. Conclusions**

196 The levels of sand, silt and clay presented differences between the types of land  
197 use.

198 Overall, the results showed that MGD varied little in different types of use.

199 In all types of land use there was a tendency for soil MGD to decrease as the  
200 depth increased.

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